november 1957

nlgi spokesman

journal of the national lubricating grease institute

NLGI Twenty-fifth Anniversary Tribute

Life, Liberty and Property
By S. GANGE

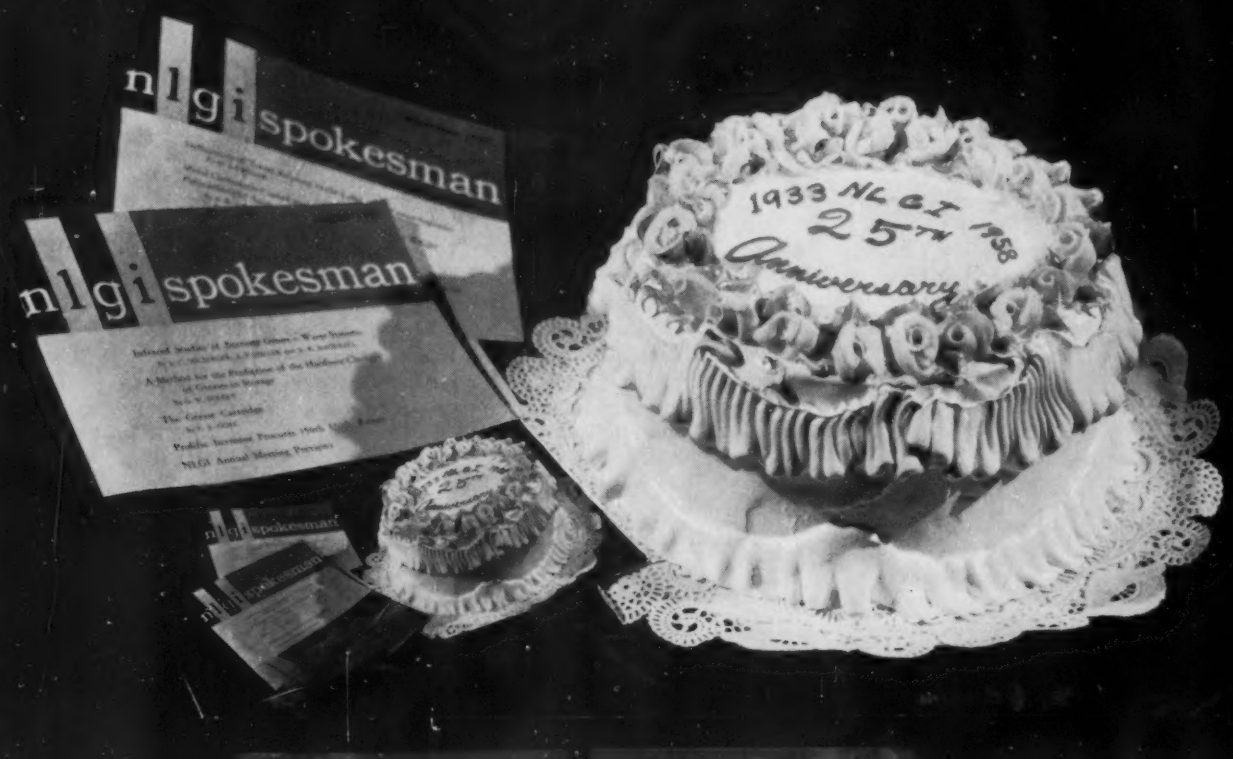
President's Address
By J. W. LANE

Newly Elected Officers and Directors Serve NLGI 1957-1958

NLGI Presents Its Past Presidents . . . 1933-1958

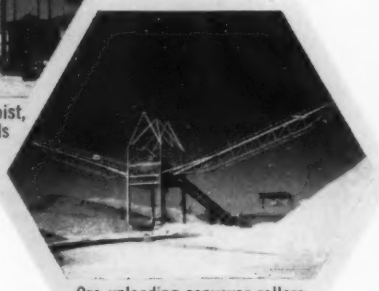
A Test for Lubricating Grease Performance Under Water-Wet Conditions
By W. H. PETERSON, J. B. ACCINELLI and T. SKEI

Deterioration of Gear Lubricants in Service
By C. R. NOLL



"In 14 months...not a single bearing lubrication failure with lithium-base grease!"

Conveyor-stacker handling moist, sticky material which builds up on the rollers.



Ore unloading conveyor rollers handling 200 tons of ore per hour.

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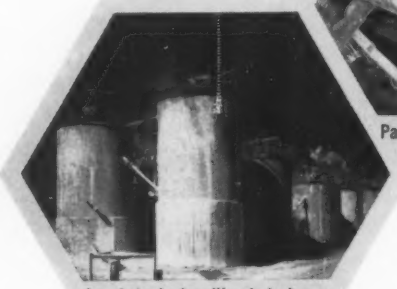
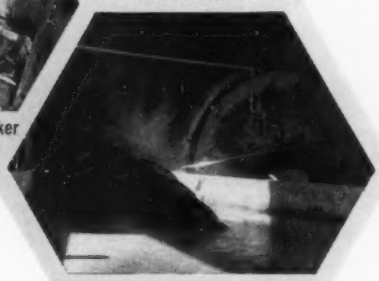
Pinion gear transmitting power from 600 h.p. motor to a ball mill.

Pan Conveyor handling hot clinker (1600°F), roller bearings in dusty, moist atmosphere.



Leach tanks handling hot slurry, agitators driven by Falk gear reducing units.



V.A. Wemco classifier, part of wet grinding system, lower bearing submerged in hot sludge.

Here's a report of our own experience with lithium-base grease under extreme industrial service conditions. Approximately 95% of the grease used in the plant of AMERICAN LITHIUM CHEMICALS, Inc., our subsidiary at San Antonio, Texas, is lithium-base, one-type grease. In fourteen months operation we have not been able to trace a single cause for bearing failure to the lubricant used. The on-the-spot photos above give graphic evidence of the rugged bearing service requirements in this plant where lithium ores are processed into high-grade lithium hydroxide, itself an important ingredient in lithium-base grease. Performance like this is why grease chemists, manufacturers, marketers and users all attest to the superiority of lithium-base... the *one* grease in place of *many* for efficient and economical operation.

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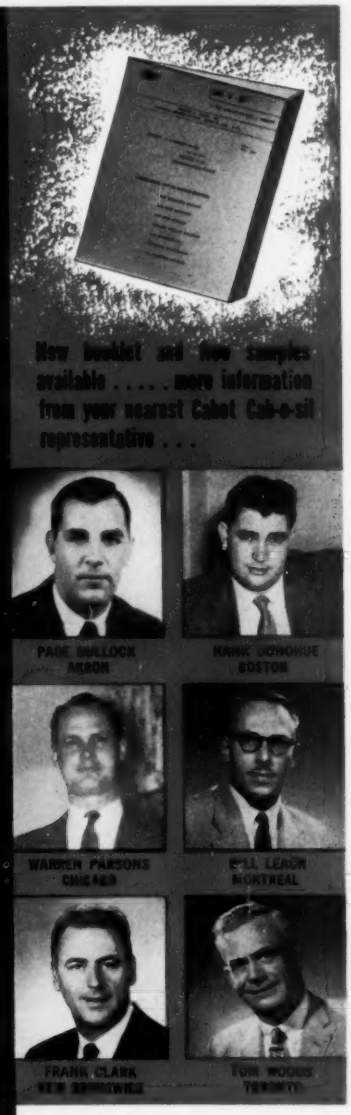
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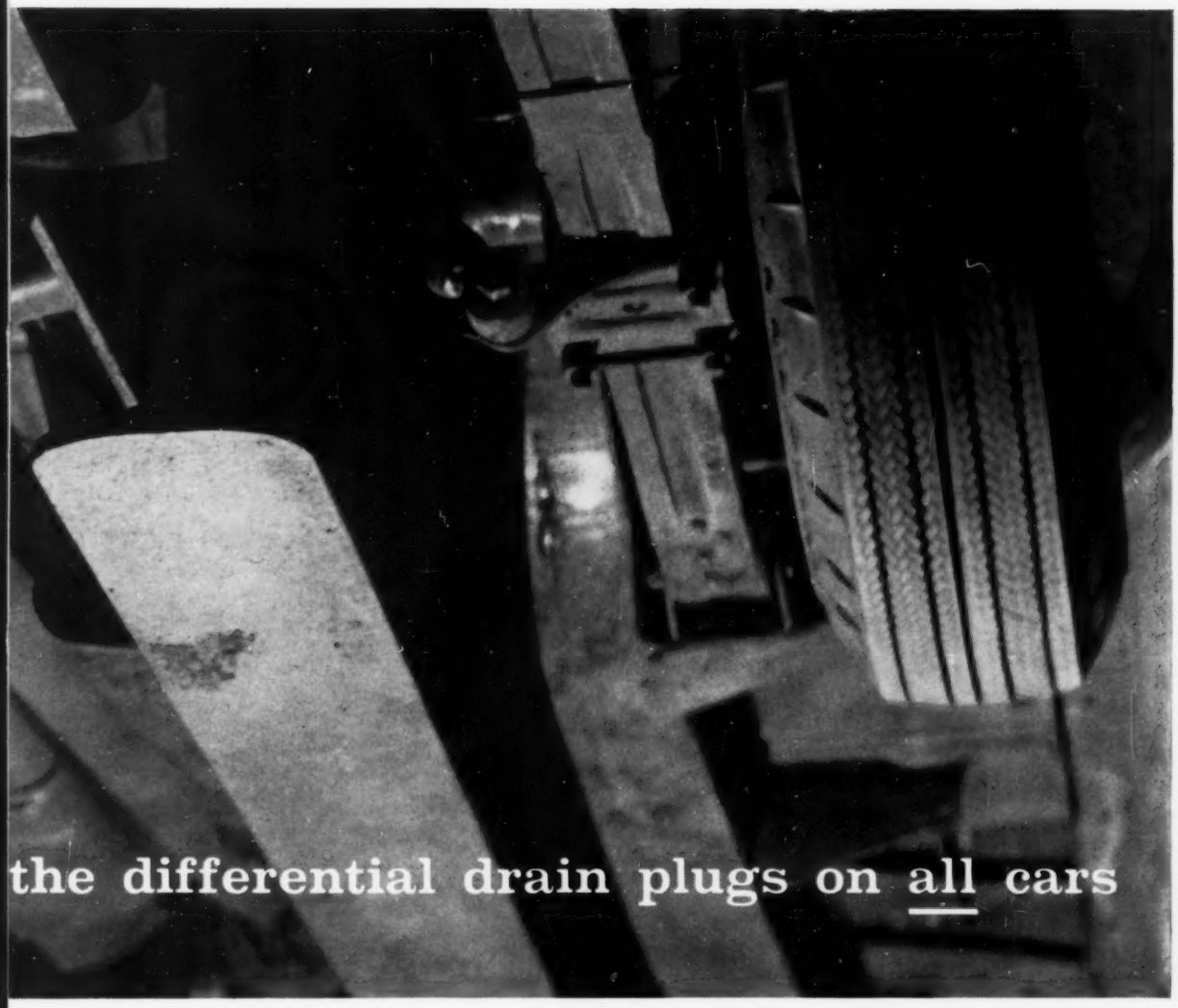

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NLGI PRESIDENT'S PAGE

By R. CUBICCIOTTI, *President*

Can We Foresee the Future?

Almost twenty-five years ago a small group of men met in Chicago to form a new association.

Who were they? They were representatives of a group of independent lubricating grease manufacturers.

What did they call themselves? The National Association of Lubricating Grease Manufacturers, Inc., later to be changed to the National Lubricating Grease Institute.

What were their objectives? As stated by the founders, the purpose was to disseminate technical information regarding the manufacture and application of lubricating greases.

Now that we are entering our twenty-fifth year, it seems a fitting occasion to ask ourselves these questions:

How successfully has the Institute achieved its aims?

What is the situation in the industry today?

What can we foresee for the future?

Let us, in this message, take the historical approach and see how far we have come along the path charted by our founders.

In order to disseminate information, one must have an audience. Our audience has grown mightily. Our membership has increased sevenfold, attendance at our annual meetings has increased tenfold, circulation of our publication, THE SPOKESMAN, is now almost 3000. Today, we have reason to believe that over 95 per cent of the U. S. grease manufacturing capacity is represented in our Institute.

Not satisfied in limiting its audience to those directly involved in the manufacture of lubricating greases, the Institute very early in its life saw the need for expanding to include those whose relationship to the manufacture of lubricating greases, while peripheral, was vital.

In this spirit, liaison was established with the Society of Automotive Engineers, the American Society for Testing Materials, the American Standards Association, the American Petroleum Institute, the American Society of Lubrication Enginers, the American Society of Mechanical Engineers, and others.

To disseminate information, one must have information, and to this end, sometimes working cooperatively with the above groups, sometimes going it alone, the Institute has inspired a large fund of knowledge which would otherwise probably not exist. Just a look at the key words in the names of some of its committees gives an idea of the breadth of the Institute's interests. Here they are:

NLGI Classification of Lubricating Greases

NLGI Research Fellowship in Colloidal Science

Definitions of Terms Peculiar to the Lubricating Grease Industry

Manual of Test Methods

Recommended Practices for Packing

Automotive Practices for Packing

Delivery Characteristics of Dispensing Equipment Containers

NLGI Educational Movie

NLGI Grease Production Survey

Yes, we have obeyed the mandate of our founders. We have "disseminated information," probably on a scale undreamed of by them.

Today, more people know more about lubricating grease than ever before. We in the Institute, in our quiet way, have reason to be proud of our contribution to the lubricating grease industry.

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News About NLGI

From the Bureau of Internal Revenue

The National Lubricating Grease Institute gives below in total a copy of correspondence from Mr. R. J. Bopp, office of Commissioner of Internal Revenue, to Mr. A. B. Garson of the Brooks Oil Company. It is felt that the interpretation given in a letter to Mr. Garson on July 12, 1957, concerning Section 314.40 of Regulation 44 (Supp. Vol. CCH—Standard Federal Tax Reports) acts to confirm the practices of many in the industry over the years. It should be counseled that the following material is presented in the NLGI SPOKESMAN as a service to the readers and should *not* be construed as an official NLGI interpretation but rather, a report on Mr. Bopp's ruling. The letter to Mr. Garson follows in its entirety:

"In our conference of June 20, 1957, we discussed, among other things, reconsideration of our ruling dated April 6, 1954, issued to your company, particularly the interpretation therein of section 314.40 of Regulations 44, relative to greases with certain ASTM penetration unit consistencies.

"In your letter dated February 12, 1954, it was stated pressure greases are customarily marketed under a worked consistency specification. You requested a ruling as to whether pressure greases having a worked consistency of less than 390 penetration units, but an unworked consistency of 375 penetration units, by the ASTM method of test, could be sold as nontaxable greases within the meaning of the regulations.

"Section 314.40 of Regulations 44, provides that oleaginous substances which are classed as grease and which contain oil are not subject to tax when of a worked consistency of less than 390 penetration units, *or* an unworked consistency of less than 360 penetration units. (Underscoring supplied.)

"In view of the specific provisions of the regulations cited, pressure greases having a worked consistency of less than 390 penetration units are not subject to tax even though their unworked consistency is 375 penetration units. Therefore, your sales of such greases may be made tax free.

"Accordingly, our ruling dated April 6, 1954, is revoked."

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- **REPRINTS — From the NLGI SPOKESMAN are available at low cost. Page forms are left standing for three months, company imprint or advertising arranged.**
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- **NLGI MOVIE—"Grease, the Magic Film," a 16-mm sound movie in color running about 25 minutes, now released. First print $600, second print $400, third and subsequent orders $200 each (non members add $100 to each price bracket).**
- **WHEEL BEARING MANUAL—"Recommended Practices for Lubricating Automotive Front Wheel Bearings." More than 90,000 copies of this booklet have been distributed throughout the world. Fifteen cents a copy (NLGI member price) with quantity discounts — company imprint arranged.**
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THE COVER

A QUARTER century cake marks the completion of the twenty-fifth annual meeting for National Lubricating Grease Institute, October 28-30, and the beginning of its 25th anniversary year. This annual meeting, with its diversified program emphasizing the increasing importance of close contact with other related industries to its own, denotes a continuing step forward in the history of the Institute. Newly elected president R. Cubicciotti considers the future goals for the Institute in his first President's Message, page 7, and J. W. Lane, outgoing chief, cites some specific achievements in his President's Address, page 13.

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Life, Liberty and Property

By S. Gange, Pacific Olive Company

IN THINKING OF our country and our American way of life, I find this to be true . . . since the dawn of recorded history ours is the only government that has taken the basic and fundamental principles of Christian living and written them into a political philosophy of government. America is great because America has been good and America will cease to be great when America ceases to be good.

Traveling around the country the last ten years one would get the impression that the original draft of the Declaration of Independence has been changed to read, Life, Liberty and Happiness guaranteed. I check on this every time I go back to Washington, D. C. I am glad to say the original draft of the Declaration of Independence still says, "Life, Liberty and the Pursuit of Happiness," which is another way of saying that neither God nor government owes anyone a living, that is up to him. Working for our living is what gives life it's meaning, it's bounce and verve. That is the rent we pay for the space we occupy while here on earth.

There is no real difference between Socialism and Communism, both are time bombs that will in time blow up our whole way of life. The only difference may be the length of the fuse. The basis of Socialism so many times seems to be equality and this word by itself means the opposite of Equality of Opportunity. Being equal in our free enterprise system, to me, means average or the so called 'common man.' Equality or opportunity to me means all that is great in America. A place where a person can climb the ladder of success as high as he can carry his own weight and where a person can get on his toes and forever reach for the stars and shoot for the moon.

In the next few years each of us in our own way, and all of us in the American way must do all in our power to find the right answers, be willing to give of our time, our energy, some of our money and all of our enthusiasm to rebuilding the moral and economic stability of our country. Individual liberty and individual freedom are our sacred trust. ■

1933 NLGI 25th

President's Address

By J. W. Lane, Socony Mobil Oil Company

IT GIVES ME great pleasure to welcome you to this Annual Meeting of National Lubricating Grease Institute. In a way, this is a very special occasion, since it is the twenty-fifth such meeting and serves as a prelude to our twenty-fifth anniversary year as an organization active in the development, improvement, application and acceptance of those very useful, necessary and sometimes exasperating materials known as lubricating greases.

Our Program Committee has arranged a diversified and interesting series of papers. If you have studied the Program at all, you have undoubtedly noticed that the papers cover technical, manufacturing, marketing and application phases, with considerable attention being directed at the contractor market specifically. The emphasis on the latter is dictated by one of the most powerful influences—self-interest—as the country sets out on a greatly-expanded road-building program generated by the Federal Aid Highway Act of 1956. While sources of data disagree somewhat, it appears at the moment that the presently projected 13-year program of interstate highway construction, plus construction of state primary and secondary roads, will embrace as a minimum some 790,000 miles and in the aggregate cost about 100 billion dollars at our present dollar-value levels (Federal funds plus State funds, already authorized and expected to be authorized between now and 1970). For these data, I have relied rather heavily on *Engineering News-Record*, the well-known trade journal serving the construction field.

This means that highway construction will be at least twice as much as in the past, possibly more, until 1970. All this activity is going to require lubricants and a lot of them. For example, the estimated requirements for gear lubricants and greases for highway construction through 1959 are 22 million pounds, a huge volume by anybody's standards. This is a volume, too, that should make us prick up our ears and make ready—to borrow from a rather well-known advertising theme, we want to help keep the countryside filled with contented contracting equipment, able to work full blast alongside contented cows engaged in meeting the demand for milk.

Continued next page

Anniversary 1958

There is an interesting sidelight to this picture also. As new and improved highways are built, they are followed by factories, warehouses, homes and other types of construction, all of which require machinery to build them. So there will be more fuels and lubricants required than just those tied in directly with road-building. These incidental volumes can be substantial; as big as road-building appears on the surface, historically it has accounted for only about ⅛ of total construction. While road-building's proportional share seems bound to increase, non-highway construction will probably continue to be predominant by a big margin. And new roads, as it happens, do not stay in new condition very long—just the annual maintenance on the additional miles of highway will cost a pretty penny.

Now I would like to tell you briefly what NLGI has accomplished during the past year. I wish it were possible to recite dozens of grand achievements—actually, things do not work out quite this way for NLGI or, for that matter, for any other group or even individuals. However, there are a few concrete and substantial advances which have been made—things accomplished for which we can all feel a sense of satisfaction. I think our principal success has been the completion and issuing of the color moving picture, "Grease—the Magic Film," of which to date approximately 45 copies have been sold. This major adventure into the field of public relations reflects great credit to the Institute, and is one that I hope will eventually be reflected in a more substantial manner by greater acceptance of, and demand for, the products which our members manufacture. Personally, I was most happy to see the moving picture turned into a reality, which is understandable, as I sweated through the chairmanship of the Moving Picture Committee for several years. I did, however, have the effective cooperation of the Committee members, to whom I am very grateful.

We have also recently concluded preliminary plans for the conduct of a survey of annual domestic lubricating grease by principal types of soap base employed, starting with the year 1957. This survey will be based on manufacturing data, and not sales, and will be con-

Newly Elected Officers and Directors Who Will Serve NLGI 1957-1958

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International Lubricant Corp.

B. G. SYMON
Shell Oil Company

ducted by an outside, completely impartial firm in such a way as to completely safeguard the individual sources of information. Results are to be reported as industry totals, only. It is expected that a similar survey and release of findings will be conducted annually.

The preliminary work has been extensive, requiring a thorough search into any legal complications and the possible mechanics of the job, as well as a bit of selling here and there to convince members that any plan finally adopted would absolutely honor the confidential nature of each and every manufacturer's replies. The survey results should prove valuable not only to grease manufacturers, but to their suppliers such as the manufacturers of ingredients, containers, cartons and similar items. Furthermore, it will also have a definite public relations value. As the trade association representing the lubricating grease industry, NLGI is often called upon to supply statistical information to various inquirers. This has not been readily available in the past, which as you may gather has proved embarrassing to our executive secretary who must cobble up the replies to such inquiries.

An excellent start has been made also in defining terms and expressions peculiar to lubricating greases. This work, first envisioned as far back as 1951, and formally instituted in 1952 by formation of a Committee on Definitions within the Technical Committee, recently submitted its first recommendations. These have been approved by the Technical Committee and tentatively accepted by the Board of Directors. This first group is not large in number, but does include important basic terms such as Apparent Viscosity, Penetration, Dispensability, Thixotropy, Feedability, Plasticity and others. The September issue of The NLGI Spokesman carries the complete report, and I can recommend it for careful reading. This project is meant to be a continuing one, and here again I am firmly convinced that the various definitions as they are approved and promulgated will be of great help not only to the industry but to the users of its products.

Finally, we have come to grips with a question of long standing concerning the legitimate field of interest of the Institute. The question, simply put, is this: "Are gear lubricants properly in the sphere of NLGI interest and activity?" I am able to state that the reply has been in the affirmative. Your Board of Directors, after study of the question through a committee headed by Mr. Hemingway, endorsed that committee's findings by voting unanimously at its May meeting that the term, "gear lubricants," includes any product which can conceivably be employed in the lubrication of a gear. Note that this is the heart of the matter—gears can be and are lubricated by oils and greases, but nothing is conveyed to indicate that NLGI should or must confine itself to gear lubricants meeting the basic definition of a lubricating grease.

I am sure that this classification of the issue will interest every member of NLGI, and that it furnishes us with new opportunities for service to the great industry which we represent.

Before this twenty-fifth Annual Meeting ends, I shall have become an ex-President of NLGI and since it seems to be the privilege of every retiring officeholder to point out what ought to be done *after* his vacation of office, I shall presume to avail myself of that privilege.

As I probe the make-up and constitution of NLGI, it seems to me that within the confines of the constitution as presently established the chances for an indefinite growth in members are somewhat limited. Therefore, an increase in stature, since it cannot come from sheer physical numbers, must come from accomplishments. We have come a long way since our modest beginnings as the National Association of Grease Manufacturers, Inc., and I need not catalog all that has been done subsequently. Our purely technical activities and interests seem to be well served, and my principal concerns are with our advances of a promotional and marketing nature. If technology produces ever-better lubricating greases, to what avail if we find our markets shrinking steadily? Those of us who sell in the passenger-car market know too well the problem involved, where there is a steady, eroding attack on grease volume through the gradual disappearance of chassis points requiring grease lubrication.

Our concern should be not only to make good products, but to find new uses for them, to package them attractively, to make them as easy to use as possible, to find and try out the means of actually convincing equipment designers and users that lubricating grease can be an effective and thoroughly dependable lubricant.

The NLGI film which will have its premiere public showing during this meeting is an excellent example of a promotional assist. It is to be hoped that we can find others equally good from time to time. Also, we need to intensify existing contacts and establish new ones, with other groups and organizations wherever a common interest may be apparent. We already have such relations with ASTM, SAE, ASA, ASLE, ASME, etc. Most of these are essentially technical in nature; I believe there are opportunities also with primarily user associations, such as contractors, truckers, bus operators, and various industrial associations.

I think this is an opportune moment to conclude this address. I would like to do so by publicly expressing my very deep appreciation to all those groups and individuals who have helped in any way to make my tenure as NLGI president as pleasant and painless as possible—the officers and Board of Directors; the various committee chairmen and individual committee members; our executive secretary, Tom Miller; and many others who, while they will be nameless here, have certainly done their bit. NLGI does not function through one man's efforts alone—it remains a living thing only through the labors of many. ■

1933 1958

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Pure Oil Company
1934-35

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International Lubricant Corp.
1935-36

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Socony-Vacuum Oil Co., Inc.
1936-37

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1937-38

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1950-51

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1951-52

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1952-53

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1956-57

MOISTURE IN ANTI-FRICTION bearings often causes their early failure due to corrosion or loss of lubricant film. Such moisture initiated bearing failures have been commonly observed in automotive, aircraft, and industrial equipment. This is especially true of grease lubricated bearings which operate under humid conditions.

The water may gain entry into a bearing either due to its immersion, or by splash such as front wheels on wet roadways, or by condensation due to daily temperature changes. Bearing seals, designed to keep such contaminants out of a bearing, wear and are often damaged so as to be ineffective. In the case of water entry by condensation no seal is effective. For complete protection of the bearing, the grease, especially when designed for multi-purpose use, must have a good over-all water-wet performance. This has recently been pointed out by several authors,[1,2,3,4,5] since many greases, especially some using inorganic gel agents, do not adequately protect bearings under water-wet conditions. For satisfactory water-wet performance a grease must not only prevent corrosion, but must also maintain adequate lubrication of the bearing. To do this it must not disintegrate or lose consistency due to water up-take. Thus, three properties need to be evaluated to determine a grease's water-wet performance: corrosion, lubrication, and water resistance.

The evaluation of these properties has been the concern of various CRC, ASTM and military specification committees and certainly has become the concern of those workers developing multipurpose and inorganic base greases. Tests for adequately evaluating grease water resistance and static corrosion

By W. H. Peterson
J. B. Accinelli
and T. Skei

Shell Development Company

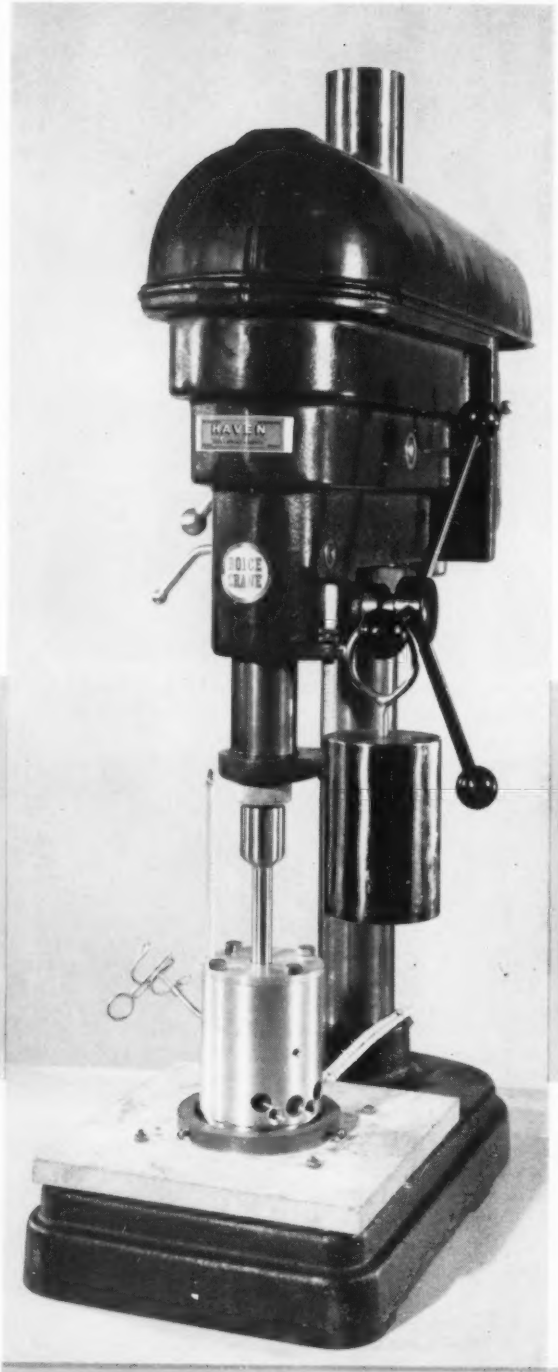

FIGURE 1 The assembled roller bearing corrosion rig —a single test in this rig usually provides adequate estimate of total water-wet performance of a given grease.

prevention have been developed and generally require only simple equipment or adaption of existing test machines. However, realistic evaluation of lubrication under water-wet conditions requires a dynamic test and the equipment designed for such a test has not been adequate.

To measure the water resistance of a grease structure often requires several tests. Among these are the Navy water absorption test, the Shell roll test with 20 per cent water added, or the ASTM worker with water added to the grease. Generally, these test results can be correlated with field performance. Experience shows that greases of adequate water resistance will not usually absorb more than 150 per cent water in the Navy test and will not exceed 230 dmm penetration value in four hours rolling with 20 per cent water in the Shell roll tester.

Static corrosion is satisfactorily measured by observing the length of time taken for corrosion to occur in the glass jar test.[5] This test has the advantage over all other corrosion tests in simplicity and in being well related to field experience. It is preferred to the salt spray and humidity cabinet tests.

Test for Lubricating Grease rformance Under Water-Wet Conditions

For determining grease performance under water-wet operating conditions previous dynamic tests were generally too mild and actually only evaluated grease wash-out and not over-all performance. Such a test is described in specification VV-L-79132-52. It was felt that the need existed for a dynamic test which would evaluate grease performance (especially lubrication) under conditions simulating realistically those present in most water-wet applications, since field experience had already shown that marginal lubrication due to heavy moisture contamination results in dynamic corrosion of the bearing, higher temperature operation and in extreme cases, bearing seizure. A rig has been recently described[3] which satisfied the requirements and this paper will describe a similar but simplified and more versatile test apparatus.

In this apparatus a bench type drill press is used to drive the test bearing, which is mounted in an enclosed housing so that contaminating water can be added. A single test in this rig usually provides an adequate estimate of the total water-wet performance of a given grease. Varying conditions of operation have been used to show the relation of inadequate lubrication to dynamic corrosion, the difference between dynamic and static corrosion, and the effect of such variables as water quantity, speed, and load on dynamic corrosion.

Water-Wet Bearing Test Apparatus

A drill press drives by means of a self-centering fiber coupling (Phillips drive) the inner race of a tapered roller bearing, which is mounted on a mandrel so that its axis is vertical, see Figures 1, 2, and 3. The mandrel has a cross notch into which the fiber coupling fits. The outer race (or cup) of the bearing is held by four setscrews in a cup-shaped mounting, and the race is centered by a closely-fitted cylindrical jig before the setscrews are tightened and the jig removed. The cup-holder is usually capped by a threaded cover piece through which the fiber coupling and drive shaft operate. This cover so encloses the bearing, when the inner race and tapers are in place, that added water is prevented from being thrown out of the system. The cup-holder (and bearing) is held loosely by its

square shaped base in the aluminum block. The aluminum block is kept from turning by a screw in a ring that is fastened to the base of the drill press.

Water is introduced into the bearing by means of a tube that threads into the cup-holder. The water enters at the outside of the outer race, runs into the bottom of the cup-holder through a cut in the cup-holder located under the outer race seat. When the water level reaches the rotating parts, it is pumped through the bearing by centrifugal force and recycled.

The load is applied by hanging weights on the horizontal drill press arm which is arranged at right angles to the axis of the drill press when the apparatus is fully assembled.

The bearing for this test (Timken cup A2126 and cone A2027), after being thoroughly cleaned with an aromatic solvent and dried, is packed with 1.2 to 1.4 grams of grease. The bearing is operated at its equilibrium temperature. If it climbs above 75° C, loss of water due to evaporation makes the results questionable. The following schedule for operating, Table I, has been selected to cover a wide range of conditions.

Each set of conditions was designed to test different severity levels, comparable in range from low water to washout under road test conditions. This variation is desirable since the performance of various greases differs with the water conditions.

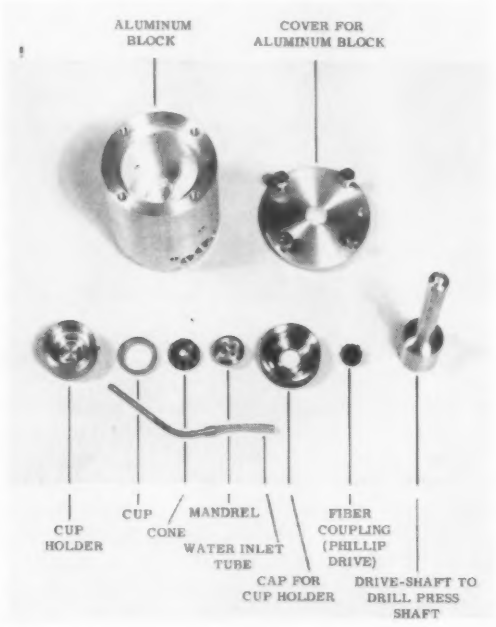

FIGURE 2 The assembly of the roller bearing corrosion rig is given in detail. The mandrel has a cross notch into which the fiber coupling fits . . . outer race of bearing is held by four setscrews in a cup-shaped mounting.

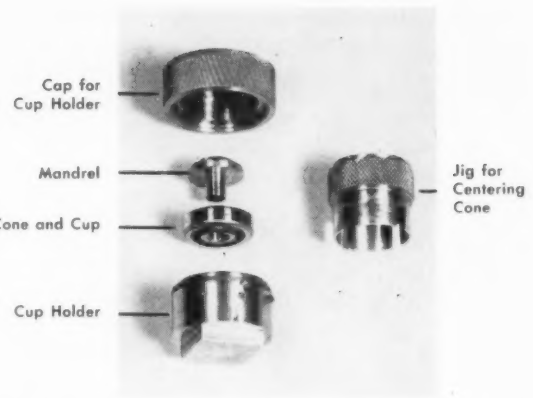

FIGURE 3 shows details of inner assembly for driving cone and cup holder of roller bearing corrosion rig.

Table 1
Schedules for Dynamic Rig Testing

	A	*B*	*C*
Speed, rpm	650	2400	2400
Load, lbs. thrust	148	148	148
Length of operation, hrs.	15½	2½	2½
Amount of "water,"*	1	4	10–15
Method of "water" addition	After 2 min. of operation water recycled cup-cap on.		Continuously. Part of water thrown out; cup-cap left off.

*The "water" used is a solution of 0.05%w NaCl in distilled water.

Inspection and Rating

All ratings (emulsification, lubrication, dynamic and static corrosion) are given on a 0 to 10 scale with 10 as perfect. The dynamic corrosion rating is given immediately after operation by inspection of the water, grease, and bearing surfaces. The worst rating is taken as the over-all dynamic corrosion rating. Colored prints of the bearings, and water samples, Figure 4, rated from 0-10, help to keep these visual ratings consistent from test to test.

The condition of the grease as to emulsification is also rated at this time. Greases vary widely in their water absorption characteristics and this test, which appears to differentiate between the extremes of mild water up-take, emulsion of grease into water, and actual breakdown, should be considered as qualitative and for just such differentiation. However, ratings of 0—breakdown, 2—heavy grease emulsion in water, 5—partial grease emulsion in water, 7—water uptake, 10—

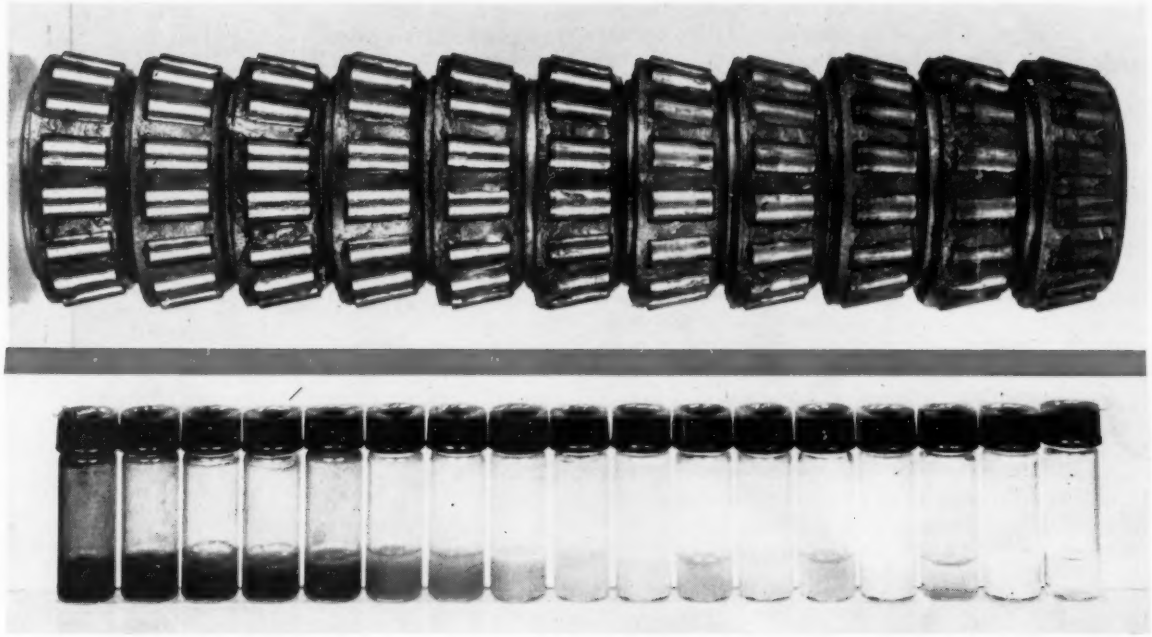

FIGURE 4 Inspection and rating—examples of water from dynamic corrosion tests rated from 0 to 10 as indicated.

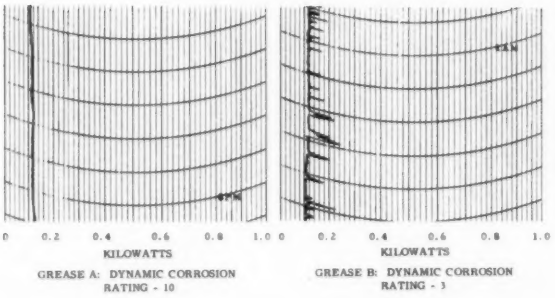
0 0.2 0.4 0.6 0.8 1.0
KILOWATTS
GREASE A: DYNAMIC CORROSION RATING - 10
0 0.2 0.4 0.6 0.8 1.0
KILOWATTS
GREASE B: DYNAMIC CORROSION RATING - 3

FIGURE 5 Power input charts illustrating the relation between erratic bearing friction (lubricant film breakdown) and dynamic corrosion results are given here.

no emulsions are used. A rating of 7 is probably more desirable than 10 as elimination of free moisture by emulsification in the grease is a recognized means of corrosion prevention.

Lubrication ratings are obtained from the manner in which the machine operated during the run. A wattmeter can be used to show the increased power required with increases in lubrication friction, see Figure 5, but the rig is so overpowered that it usually operates without difficulty on failing lubricants. Therefore, the bearings are examined for score or seizure marks and ratings of 0, 5 and 10 given.

Following initial inspection the bearing is put away in a covered petri dish and the water from the test poured over it. After approximately sixteen hours

Table 2

Ratings for Water-Wet Performance of Grease

Grease Characteristic	*Rating*	*Observations*
Dynamic Corrosion*	0	Heavily corroded.
	10	No corrosion.
Static Corrosion	0	Heavy stains, pits.
	2	Heavy stains, no pits.
	5	Moderate stains.
	8	Occasional light stains.
	10	No stains.
Water Absorption	0	Very pronounced breakdown.
	2	Heavy water up-take, grease emulsified into water, no breakdown.
	5	Moderate up-take, slight emulsification into water.
	7	Very slight up-take
	10	No water up-take.
Lubrication	0	Poor (very high increase in friction, seizure).
	5	Marginal (occasional high increase in friction, heavy score marks).
	10	Good (low friction, only light score marks).

(overnight), the bearing is again inspected and a static corrosion rating given. The preceding Table 2 summarizes the ratings used.

Experiment and Discussion

Difference of Dynamic Corrosion from Static

Corrosion that occurs during the operating period of a water-wet bearing has been termed "dynamic corrosion." This differs from corrosion during non-operating periods (static corrosion). Dynamic corrosion shows a general discolor over the bearing surface and the water and grease are often discolored as shown in Figure 4. Static corrosion occurs at points of water film contact between the resting rollers or balls and the races or cage. Etched or stained areas with sharp boundaries result, as shown in Figures 6, 7 and 8. While some greases allow corrosion under either condition, other greases permit dynamic corrosion and prevent static or vice versa, as shown in Figure 9. Here two different greases were formulated with different additives. Grease I was gelled with soap and grease II gelled with an inorganic agent. Corrosion inhibitors were added to these greases making formulations A, B, and C for each grease.

FIGURE 6 Truck-trailer wheel bearing cones showing severe static stains caused by moisture in wheel hub.

FIGURE 7 Truck-trailer wheel bearing cone failures resulting from moisture corrosion occurring during the non-operating periods are shown.

Relation of Dynamic Corrosion to Lubrication

Different additives are required to prevent dynamic corrosion than those required to prevent static. Additives which prevent dynamic corrosion are often in the class popularly called "lubricity" agents. This relates the occurrence of dynamic corrosion to improper lubrication and it is found that the prevention of dynamic corrosion depends on the maintenance of a good lubricating film on the bearing surfaces.

Operation in the wet bearing rig with a highly refined oil results in a high degree of dynamic corrosion, large power requirements and high temperatures. Often seizure occurs. This indicates water is displacing the oil film from the bearing surface. The addition of a surfactant which is more strongly adsorbed on steel

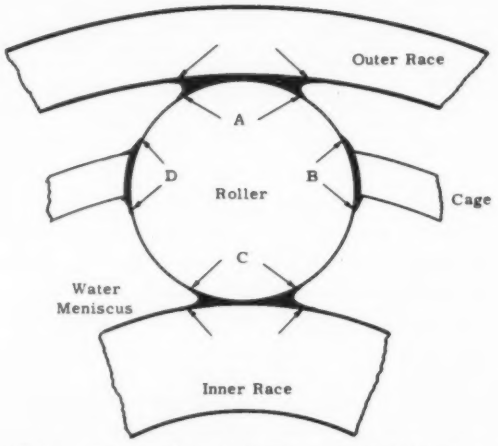

FIGURE 8 Cross-sectional sketch of wheel bearing assembly shows areas attacked by moisture in non-operation.

than water prevents this. Figure 10 shows that about 0.4%w of surfactant (in the case an amine) prevents dynamic corrosion, but that lower concentrations allow it to occur. The figure also relates dynamic corrosion and borderline lubrication. With increasingly poorer lubrication the operating temperature increases. Thus dynamic corrosion is the first visual indication of marginal lubrication.

Effect of Operating Variables on Dynamic Corrosion

The important variables affecting dynamic corrosion are temperature, time, load, speed, and quantity of water. In the rig test ambient temperature was used although provision for higher temperature operation is made. An equilibrium operating temperature of 25 to 38°C was usually reached. Temperature rises above 40°C indicate poor lubrication. Occasionally high bearing temperatures would cause evaporation of the contaminating water. In such cases no corrosion would result, since no water was present but such poor lubrication is an undesirable property in a grease.

Lengthening the running period increases the severity of corrosion, but does not cause its initiation where a grease is sufficiently water stable. In contrast, the length of time to first corrosion is used to measure static corrosion resistance, although here, too, increased time increases the severity of attack. This is shown in Figure 11 for static conditions.

Increased load increases dynamic corrosion, but each grease has a characteristic load-corrosion relationship as shown in Figure 12. Normal bearing loads are generally below the region of high dynamic corrosivity. For rig test conditions, a relatively high load was selected in order to increase the test's sensitivity. Bearing loads, either while operating or standing, do not appreciably affect the degree of corrosion (static) ob-

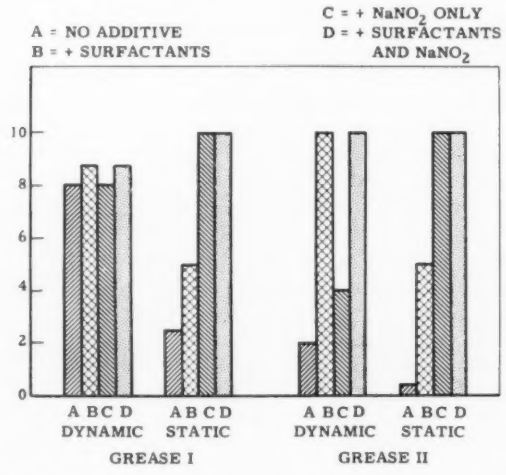

FIGURE 9 The effects of corrosion inhibitors in wheel bearing greases here — two different greases were formulated — grease I with soap, grease II, inorganic agent.

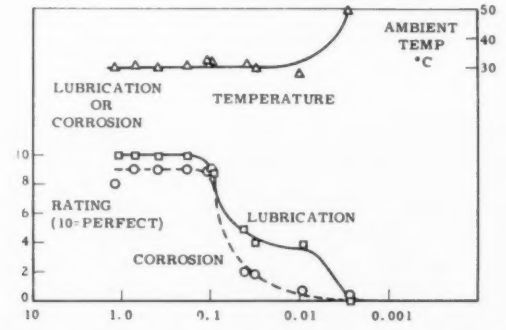

FIGURE 10 Corrosion and lubrication as effected by amine concentration — 0.4% w prevents corrosion.

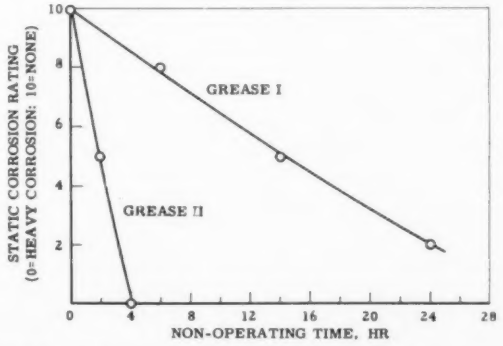

FIGURE 11 shows the effect of time on static corrosion.

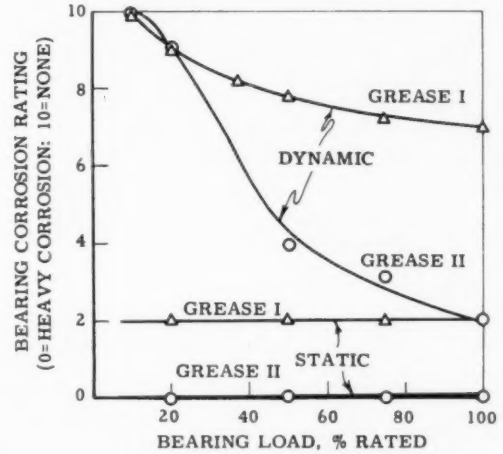

FIGURE 12 shows effect of load on bearing corrosion.

tained during non-operating periods.

Increased speed also increases dynamic corrosion. Figure 13 shows that for some greases there appears to be a critical speed beyond which the severity of dynamic corrosion increases rapidly. In these experiments the duration of the test remained unchanged, thus the total bearing revolutions increased with increasing speed which may account for some of this effect. However, operation for an equivalent number of revolutions at lower speed did not produce as severe dynamic corrosion. In contrast to this, static corrosion was unaffected by speed.

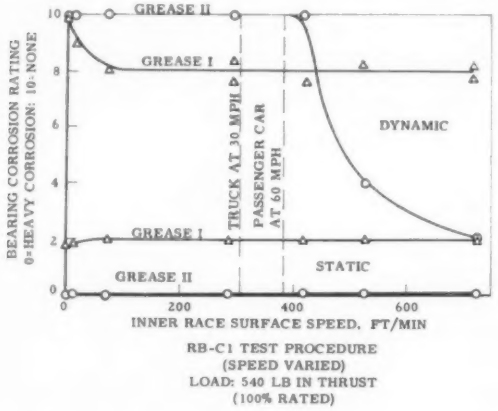

FIGURE 13 gives effect of speed on bearing corrosion.

The quantity of contaminating water a bearing may be subjected to in the field can vary from the small amount resulting from condensation to complete submersion with water pumping freely through the bearing. This last condition is very unusual since seals or shields and other arrangements usually limit water ingress. The conditions suggested for operating the rig use three different quantities of water, i.e., the amount in C (Table 1) simulates water washing freely through the bearing. Very few greases are able to withstand wash-out under these conditions.

The more general conditions of water contamination are those of limited amounts of water and may be divided as to whether the quantity of water is larger or smaller than the amount the grease can completely emulsify. Conditions in B (Table 1) represent limited amounts of water, usually in excess of the emulsification value; and in A represent the amount of water usually less than the emulsification value. Conditions in B are generally more severe than those in A because unemulsified water promotes static corrosion. Emulsification of the contaminating water has been pointed out previously as a means of preventing corrosion.

Relation of Rig Test to Field Results

Field results correlate well with predictions from rig tests. Testing was done both in truck and trailer wheels and in the front wheels of passenger cars. In the passenger cars thirteen ml of contaminating water (containing 0.05 per cent NaCl) was added after a break-in run of approximately five miles. Ratings were made after 500-1000 miles operations over a two week period. These tests have been termed semi-field for the reason that the water was deliberately added. In the truck wheels water contamination was left to chance, but only those wheels were rated which had visible evidence of water entry. In the table an overall corrosion rating has been used, since separating field originated corrosion as to dynamic or static is sometimes difficult. The ratings summarize results from several different wheels in most cases and represent 50 to 100 thousand miles of truck wheel operation.

Both soap base and inorganic base greases were tested. The performance of these greases in various conventional water-wet tests is summarized in Table 3, while the results for the wet bearing rig tests and for field tests are summarized in Table 4. Comparison of field results in Table 4 with the conventional corrosion tests of Table 3 shows these tests do not predict field performance as well as the results of wet bearing rig tests. Also the rig test emulsion ratings (Table 4) while not as selective as the conventional water emulsion values, are a reliable index to this property of the grease.

Conclusions

1. Water-wet performance of a grease may be predicted from a test made in the water-wet bearing test rig.

Table 3
Grease Ratings In Current Water-Wet Performance Tests

Type Grease or Gel Agent	*Water Emulsion Value*	*Spray Cabinet hrs. to 1st rust*	*Water Washout Test ASTM D1264-53T, %*	*Glass Jar Corrosion hrs. to 1st rust*
Purchased silica	60	100+ at 95°F	0.5 pass	4
Purchased clay	90	96 at 94°F	20.0 pass	24
Shell inorganic base grease	67	240	0.5 pass	500+
Lithium 12-hydroxy stearate	30	132 at 95°F	6.9 pass	24
Lithium 12-hydroxy stearate inhibited	45	——	20.0 pass	500+
Sodium stearate	decomp.	washes off	——	——

Table 4

Grease Ratings in Water-Wet Rig Tests and in Field Tests

	*Ratings in Water-Wet Rig Test**				*Wheel Field Ratings**	
			Corrosion			
Type Grease or Gel Agent	*Emulsion*	*Lubrication*	*Dynamic*	*Static*	*Truck*	*Passenger*
Purchased silica	7	5	0	5-2	8	5
Purchased clay	5	5	4	2-5	2	–
Shell inorganic base grease	7	10	9	10	10	10
Lithium 12-hydroxy stearate	10	5	5	5	2-5	2
Lithium 12-hydroxy stearate inhibited	7	10	9	10	10	10
Sodium stearate	decomp.	10	4	8	10†	10

* 10 = perfect.

† Slight rust color in grease and slight stains.

2. Water-wet performance of a grease requires evaluation of
emulsification
work stability
corrosion
and lubrication in the presence of water.

3. Corrosion may occur during operation of the bearing (dynamic) and not during non-operating periods (static).

4. Dynamic corrosion is indicative of borderline lubrication.

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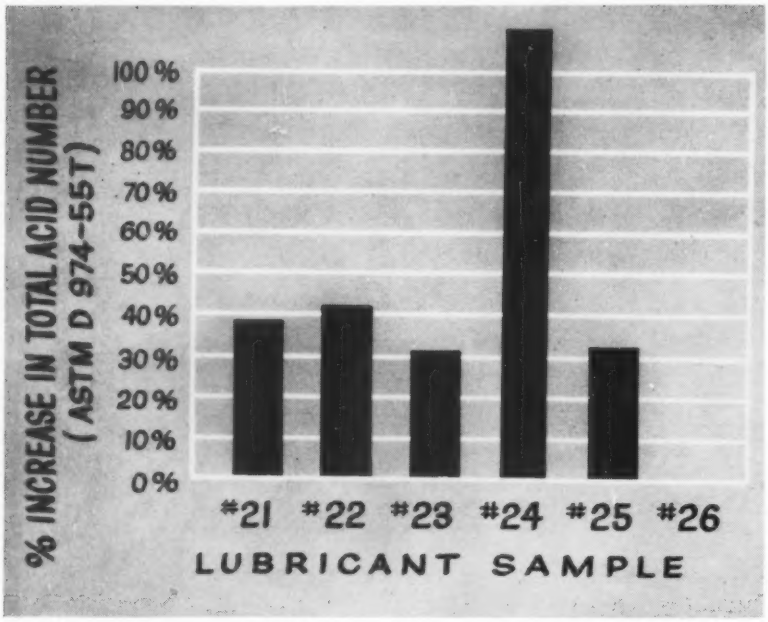
About the Authors

W. H. Peterson *received his B.S. degree in chemical engineering from the University of California in* 1936. *After graduation he joined the research staff of Shell Development company in Emeryville. For the past nine years Peterson has been actively engaged in grease research, of which some of the results have been published in various scientific and patent literature, including articles appearing in NLGI Spokesman.*

J. B. Accinelli *received his B.S. degree in mechanical engineering from the University of California in* 1941. *After serving five years in the U. S. Navy he joined Shell Development company in* 1946 *as engineer in the research division. In this capacity Accinelli has done research work on the lubrication of gears and rolling contact bearings. For the past nine years he has been particularly involved in studies of the various aspects of grease lubrication of rolling contact bearings at the Emeryville center.*

T. Skei *is group leader in fuels research in the chemical section of the Shell Oil company Wood River research laboratory. His work on grease formulations containing corrosion inhibitor was done while he was a member of the materials engineering and corrosion department of Shell Development company. Skei received his B.S. degree at California Institute of Technology and Ph.D. in chemistry at UCLA in* 1942. *Following several years as research associate for the NDRC and instructor at Northwestern University, Skei joined Shell Development at Emeryville Research Center.*



CHARTS illustrate the maximum amount of deterioration experienced by lubricants.

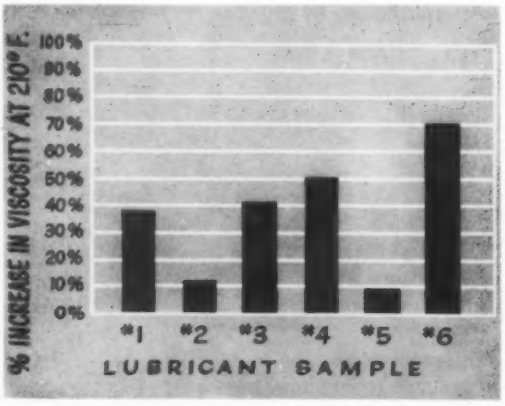
By

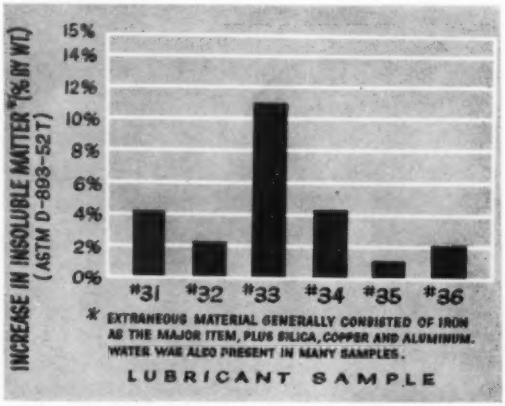
C. R. NOLL

Gulf Oil Corporation

Presented at the
American Petroleum Institute
Lubrication Committee
Meeting, February, 1957

Deterioration of Gear Lubricants in Service





THE AUTOMOTIVE GEAR lubricants panel of the A.P.I. Lubrication Committee has been attempting to secure some typical samples of used gear lubricants from authentic field tests in order to demonstrate the amount of contamination and deterioration which actually takes place in lubricants during relatively short periods of actual service.

Through the good cooperation of Mr. Norman Klein and the Ordnance Department, our panel was supplied with samples of all used experimental gear lubricants taken after 5,000 and 10,000 miles of service in the trucks employed in the 1956 ordnance gear lubricant field tests conducted at Yuma, Arizona. These used lubricants were analyzed by our laboratories for the usual chemical and physical characteristics. Samples of the respective fresh lubricants were also supplied, thus enabling us to determine the degree of contamination, breakdown, and loss of potency of the various products in this relatively short period of service.

While it is true that the conditions under which these tests were run might be considered rather severe—the inspections do show some interesting facts in regard to what did happen to these lubricants in this type of operation.

We have prepared several charts to illustrate the deterioration of product which took place in these runs, with subsequent scoring of gears and fouling of gear cases. Time does not permit showing all of the data, but I believe you will be interested in the extent to which these quality lubricants did become contaminated and lose their ability to protect gears during this test. The charts illustrate the *maximum* amount of deterioration experienced by the respective lubricants in the several gear sets of ¾ ton trucks after 5,000 and/or 10,000 miles of service. We want to emphasize that the identity of the respective lubricants has been masked and no attempt should be made to judge the relative quality of one lubricant over another from the charts because the conditions of temperature and operation in one unit might have been quite different from those experienced in another.

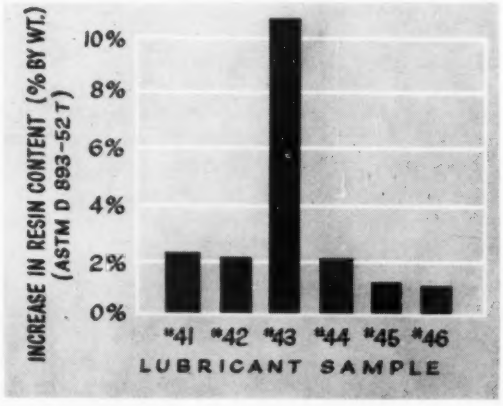
All tests are by standard A.S.T.M. procedures.

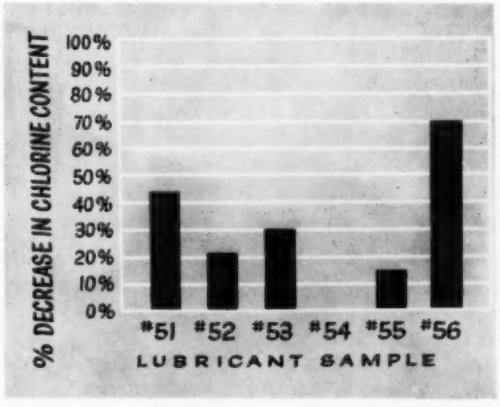
It has been seen that after relatively short periods of use there has been a complete disturbance of the original balance between the effective chemical constituents of the additives used in these lubricants. This is important, as I am advised that proper balance between the required chemicals in multipurpose gear lubricant additives plays an important part in their ultimate satisfactory performance.

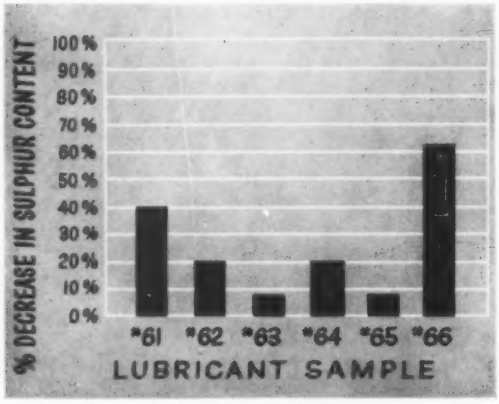
We are rather confident that no manufacturer would ever think of placing contaminated and deteriorated material of the above description in his new axles at the factory. Similarly we do not believe that he would recommend the continued use of worn out lubricants in the cars of his manufacture, if he felt that they might be as badly contaminated as the above described products. The proposition naturally follows then, that it would be to the best interests of all concerned, including the car manufacturers, the oil companies and our mutual customer—the car owner, if recommendations were made to drain contaminated gear lubricants after they have given reasonable service, and replace them with fresh, clean products having adequate protective qualities.

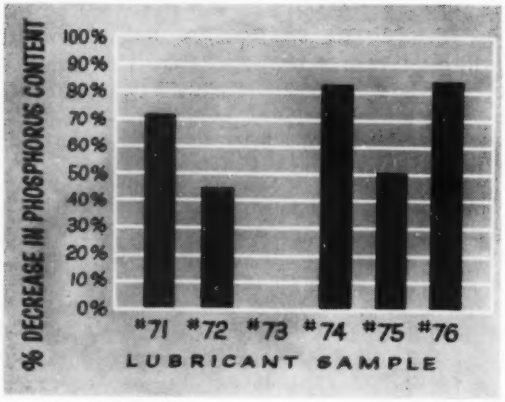
To accomplish this efficiently it would also be helpful if all automotive designers would see their way clear to provide proper drain and fill plugs in the rear axles of their manufacture which would permit service station attendants to perform a quick and thorough job of replacing contaminated lubricant.

As the charts show, these quality lubricants did suffer severe contamination and loss of load carrying ability—after even a comparatively short period of operation. Replacement costs of automotive rear axles, which might be necessary due to the continued use of unsatisfactory, contaminated and deteriorated





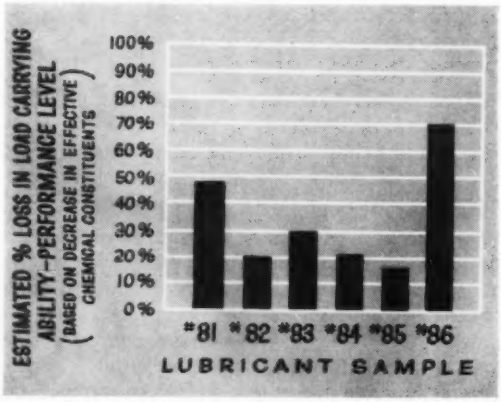




Deterioration of Gear Lubricants in Service

Lubricant	A	B	C	D	E	F
% Increase in Vis. at 210	38	11	41	50	9.5	70
% Increase Total Acid No. (ASTM D-974-55T)	38	42	31	110	33	
Increase in Insolubles* (% by Wt.) (ASTM D-893-52T)	4.12	2.46	11.8	4.66	1.9	2.0
Increase in Resins. (% by Wt.) (ASTM D-893-52T)	2.52	2.24	11.76	2.09	1.8	1.4
% Decrease in Chlorine Content	44	21	30		15	70
% Decrease in Sulfur Content	40	20	8	20	8	63
% Decrease in Phosphorous	72	45		83	50	84
Estimated % Loss Load Carrying Ability (Based on loss of effective chemical constituents)	47	20	30	21	17	70

*Extraneous material generally consisted of iron as major constituent, silicon, aluminum and copper. Water was also present in many samples.



lubricants, could cost the car owner around $150 per job of repairs, plus the incurrence of customer ill will.

Again, we believe the better way is to recommend the draining and disposal of old, worn out gear lubricant after reasonable mileage, and replacement with a fresh charge of new, uncontaminated lubricant. This applies to both the rear axles and regular transmissions of automotive vehicles. Rear axle gear lube replacement service costs the average car owner only $1.50 per change, and this seems to be relatively low cost insurance against the possible failure of expensive rear axles.

In offering the above comments, we do not presume or claim to present any particularly new thoughts, as we all know that lubricants do deteriorate in service. This information merely reaffirms the considerable extent to which lubricants do become contaminated in rather short mileages and that, unless replacement is made on a reasonable basis, you simply don't have the protective properties you need or may think you have in your rear axles and gear sets. In fact, you may have material in the cases which actually contributes to wear, corrosion and failure, rather than a product giving the necessary protection available from fresh, or reasonably fresh, lubricants.

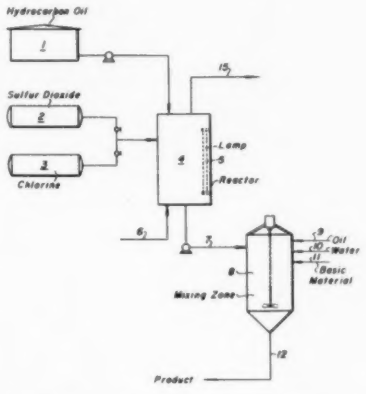
About the Author

C. R. Noll *is coordinator, product application for Gulf Oil corporation. Noll has been associated with Gulf since 1924, following his graduation from the University of Pittsburgh with a degree in petroleum engineering. After several years of service as a lubrication engineer in the automotive division of lubricating sales, he was appointed manager, lubricating sales, automotive division. Since that time he has served as director, automotive products engineering and coordinator. Noll is a member of SAE and API and at present is chairman of the API automotive gear lubricants panel of the Lubrication Committee.*

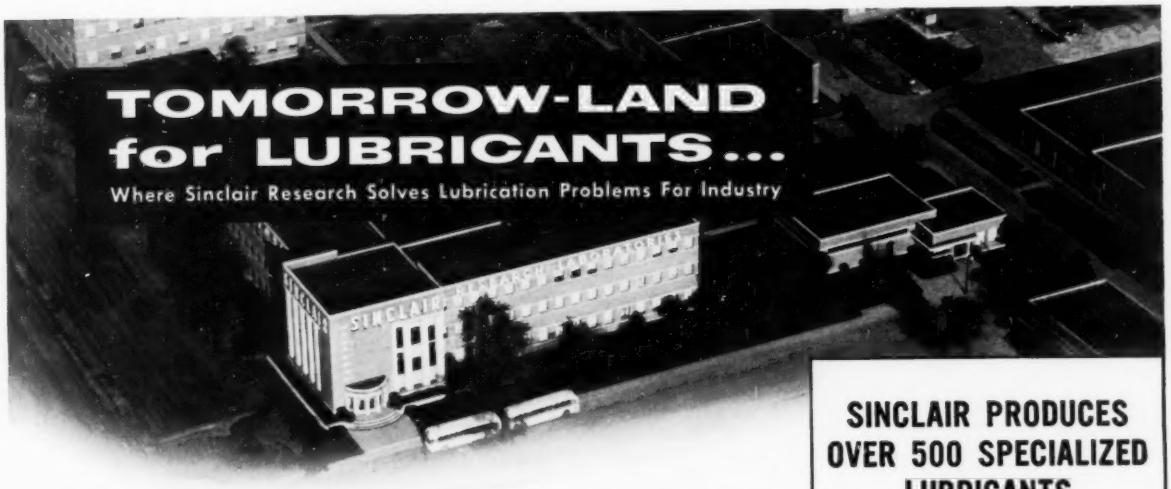
Patents and Developments

Gel Compositions

U. S. Patent 2,794,003 issued to H. E. Cier and H. G. Schutze, assigned to Esso Research and Engineering company. Gelation agents constituting the metal derivatives of sulfonyl chlorides of saturated hydrocarbons are prepared for thickening crudes, naphthas, kerosene or lubricating oil fractions. Even halogenated hydrocarbons can be readily thickened. The gel added to the oil comprises 0.1%-23% of water and a product obtained by mixing an oil soluble saturated hydrocarbon sulfonyl chloride, the hydrocarbon containing over 6 carbon atoms per molecule and ranging upwardly to paraffin wax hydrocarbons, with less than a stoichiometric amount of a basic inorganic compound of a metal, such as sodium, potassium, calcium and aluminum, the amount of the basic compound being sufficient to provide a gel-forming amount within the range of about 0.1%-45% of a metal derivative of the sulfonyl chlorides. The process involved in making the gelling agent is outlined in the adjacent flow sheet. The hydrocarbon from which the sulfonyl chloride is to be formed is drawn from vessel 1, and will constitute a paraffinic or naphthenic hydrocarbon having over 7 carbon atoms. Sulfur dioxide from vessel 2 and chlorine from vessel 3 are brought together with the hydrocarbon in reaction zone 4 equipped to permit conduct of the necessary photochemical reaction, using lamp 5 for actinic energy. The hydrocarbon sulfonyl chloride formed is retained in the reaction zone while unreacted gases are removed through line 15. Complete removal of these gases may be ef-



OUTLINE of gelling agent process.



Located at Harvey, Illinois, is one of the most extensive installations of its kind in the world—Sinclair Research Laboratories. These facilities are an important part of Sinclair's investment in the future. Here is where Sinclair engineers and chemists work to develop new products and improve the quality of existing ones. At these famous laboratories were developed the Sinclair lubricants now solving difficult problems in all branches of industry. If you have a special lubrication problem, write today to Sinclair Refining Company, Technical Service Division, 600 Fifth Avenue, New York 20, N. Y.

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EMERY 3033-S
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a new-type diester base for synthetic lubricants

Emery 3033-S is a new-type dipropylene glycol diester based on pelargonic acid, a unique, C_9, saturated, monobasic acid.

It is currently in use or under test in the following three areas: 1) Synthetic greases for spec. Mil-G-3278-A Low Temperature Aircraft Grease; 2) Low-cost blending component for synthetic low-temperature lubricating fluids meeting Mil-L-7808 C; and 3) synthetic lubricant base fluid for civilian lubricants in aircraft, automotive and specialty uses.

Since 3033-S is based on a relatively low-cost acid, pelargonic acid, long-range economics are favorable. Also, availability is not contingent on strategic, imported raw materials since pelargonic acid is made from abundantly available domestic fats and oils.

Though 3033-S is in a development stage, it is available in tankcar quantities on reasonable notice.

Mail coupon below for Technical Bulletin titled "Emery 3033-S Lubricant Ester" for complete characteristics and performance data in synthetic greases and fluids.

Emery Industries, Inc.
Dept. E-11A Carew Tower
Cincinnati 2, Ohio
Please send Development Product Bulletin #60 on Emery 3033-S.

Name.....
Company.....
Address.....
City.....State.....

Emery

Development and Service Department
Emery Industries, Inc.
Carew Tower, Cincinnati 2, Ohio

fected by introducing inert gas (nitrogen) through line 6. The sulfonyl chloride product is removed through line 7 and passed to agitation zone 8, into which oil desired to be gelled is introduced through line 9, together with water through line 10 and the basic metallic compound (e.g. hydroxide) is introduced through line 11. The gelled product is removed through line 12.

Sodium or Lithium Soap and Indigo as Lubricating Grease Thickeners

U. S. Patent 2,791,560 issued to John P. Dilworth and James R. Roach, assigned to the Texas company. Indigo (5%-20%) in particle size of not more than one micron in diameter, together with 5%-20% of a sodium (or lithium) soap of a relatively low molecular weight soap-forming acid, are used in proportion of 2:1 to 1:2, respectively, as a thickening agent for lubricating greases. Soaps of fatty acids having 12-16 carbon atoms per molecule are used, preferably including a predominent proportion of myristic acid which appears to exert a synergistic effect in combination with indigo. A wide temperature range grease may be prepared using, as the oil medium, a polyester obtained by reacting a mono- or poly-alkylene glycol with a dicarboxylic acid and a monohydric alcohol (U.S. Patent 2,628,974). A typical grease contains 35% indigo, 1% diphenyl p-phenylenediamine, 3% tricresyl phosphate, 4.3% mineral oil and 56.7% synthetic ester.

Greases by In Situ Alkali Fusion of Alcohols

U. S. Patent 2,801,971 issued to J. H. Bartlett, A. J. Morway, L. A. Mikeska and S. G. Gallo, assigned to Esso Research and Engineering company. Stable greases are claimed to be produced by at least supplementing fatty acids in the soap thickener by a fusion product of high molecular weight alcohols with alkali at 500°-560°F. for a time sufficient to form the alkali metal of the acid corresponding to the alcohol employed. The chemical reaction taking place is as follows:

$$RCH_2OH + MOH \rightarrow 2H_2 + RCOOM$$

wherein R may be a radical containing 10-30 carbon atoms and M is an alkali metal such as Na or K. Preferred alcohols are those available in large quantities as intermediate or final products of the Oxo synthesis. The distillation bottoms obtained in the successive oxonation, hydrogenation and distillation of mono-olefins having 7-30 carbon atoms or more per molecule are preferred. The fusion is conducted in presence of the lubricating oil vehicle, preferably in presence of high molecular weight fatty acid or "complex" acids.

Greases Obtained by Alkali Fusion of Ether Alcohols

U. S. Patent 2,801,972 issued to J. H. Bartlett, A. J. Morway, and L. A. Mikeska, assigned to Esso Research and Engineering company. Ether acid grease thickeners are prepared by fusing high molecular weight ether derivatives having a primary alcohol group with caustic alkali, preferably in presence of lubricating oil. Fusion takes place at 500°-575°F. when the following reaction takes place:

$$ECH_2OH + MOH \rightarrow 2H_2 + ECOOM$$

wherein E is an ether radical containing 10 or more carbon atoms and M is an alkali metal such as sodium or potassium. Ether alcohols useful for this purpose are obtained as intermediate or final products of the Oxo synthesis involving catalytic reaction of olefins with carbon monoxide and hydrogen at 300°-400°F. and 2500-4000 psig. Specific examples of such ether alcohols include n-butyl ether of tetradecapropylene glycol, nonyl phenyl monoether of decaethylene glycol, octadecyl monoether of dodecaethylene dodecapropylene glycol, etc. Fusion may be carried out in presence of high molecular weight fatty acids or "complex" acids.

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Newer pelargonate and azelate diesters offer additional advantages in formulating to obtain special characteristics as well as lower cost with no sacrifice in performance. Although these are presently in development stages, they are available in tankcar quantities.

An equally important advantage for azelates and pelargonates is their ready availability. Both are derived from abundantly available domestic tallow and thus are not dependent on foreign raw-material sources or strategic stockpiling.

For detailed information on any of these products, mail coupon below.

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Cincinnati 2, Ohio

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People in the Industry

New Additions in Gulf Oil's Petrochemical Department

John T. McConnell and James K. Sorgini have joined the chemical marketing group of the petrochemicals department, Gulf Oil corporation.

Mr. McDonnell, after October 1, will be located at Houston, Texas, where he will represent Gulf's petrochemical marketing interests in the Gulf Coast area.

Mr. Sorgini will be located in the general office in Pittsburgh and will be engaged in the marketing of petroleum additives and other chemicals.

A native of Tulsa, Oklahoma, Mr. McDonnell attended Villanova college and graduated from the University of Oklahoma with a B. S. degree in chemical engineering in 1946.

Prior to this, he was employed by the Warren Petroleum corporation for eleven years as an LP-gas sales engineer; as an engineer in the research department; and in petrochemicals and natural gasoline sales. He is a member of the American Institute of Chemical Engineers.

Mr. Sorgini is a native of Philadelphia, Pa., and received a B. S. degree in chemistry from the Philadelphia College of Pharmacy & Science in 1952. He also attended Temple university and Pennsylvania State university, taking special courses in chemistry and related subjects.

Joined Company in 1953

He joined Gulf in 1953 at the Company's Philadelphia refinery, becoming a member of the special instruments group at the refinery technology laboratory there, and has served in that capacity until his most recent appointment.

The appointments of both McDonnell and Sorgini are in keeping with the Gulf policy of increasing emphasis on the manufacture and sale of petrochemicals.

Dixon Crucible's Youse Elected ASLE Treasurer

Earl L. Youse, group chemical engineering leader for the Joseph Dixon Crucible company, Jersey City, N. J., has been elected treasurer of the New York section of the American Society of Lubrication Engineers for the 1957-58 season.

Mr. Youse previously served as a member of the organization's educational committee. He helped to organize courses in lubrication engineering held in the Texas Oil company's auditorium in New York City.

He previously was a member of the Detroit section of the American Society of Lubrication Engineers.

Mr. Youse has been with the Dixon company for two years. He is a resident of Berkeley Heights, New Jersey.

Bain, U. S. Steel Executive Retires

Dr. Edgar C. Bain, assistant executive vice president – operations, United States Steel corporation, retired at the end of September after nearly 30 years of service with the corporation, it was announced by Harvey B. Jordan, executive vice president–operations.

Dr. Bain began his career with United States Steel corporation in 1928 when he was asked by Dr.

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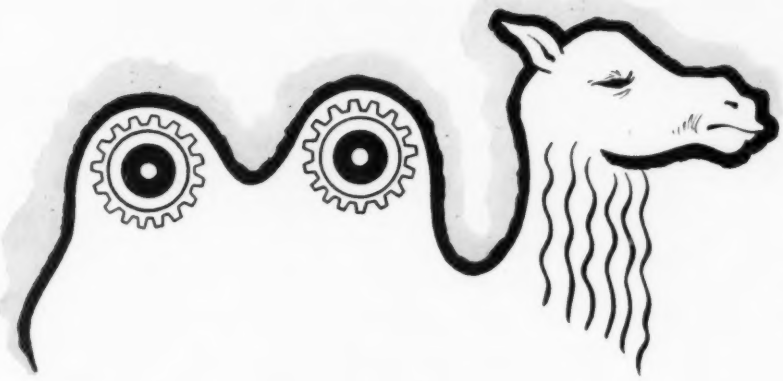

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With Research Comes Quality, With Quality Comes Leadership

John Johnston to head the metallurgical department in the newly-formed research laboratory at Kearny, New Jersey, in which capacity he served until 1935 when he became assistant to vice president of United States Steel corporation. In 1943 he was named vice president—research and technology of Carnegie Illinois Steel corporation. In addition to retaining this title in United States Steel corporation upon its reorganization in 1952, Dr. Bain was also appointed chairman of the research policy committee. He assumed his present duties as assistant executive vice president—operations on July 1, 1956.

Trauth Named Division Manager for Darling

Darling & company has announced the appointment of Mr. R. P. Trauth as manager of the chemical division. Mr. Trauth is succeeding Mr. Weatherhead who retired October 1st. It also announces the appointment of Mr. L. Strauf as sales manager of Darling's chemical division which produces stearic, oleic, fatty, and hydrogenated fatty acids as well as glycerides and specialty tallows for industry.

Almost everything that moves either in actual operation or in the process of its making . . . from gate hinges to tractor wheels . . . depends upon grease. That is why lubricants should be bought with care. You can always depend upon Deep Rock highest quality greases and lubricants. They are manufactured to give top lubrication to all moving parts.

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Roberston, Garlock Packing Company, Services Ohio Sales

J. B. Sewell, vice president in charge of sales for the Garlock Packing company, Palmyra, New York has announced that Harry A. Robertson, Jr., has been assigned a new sales territory in the central section of Ohio. He will work out of the Cleveland branch.

Robertson graduated from the University of Colorado with a B.S. in business administration and received his electrical engineering training with the United States Navy.

Oil Progress Queen Is Kay Fitzgerald

Kay Fitzgerald, with the International Lubricant corporation was chosen queen of Oil Progress Week by the Desk and Derrick club, organization of women in the petroleum industry. She reigned over the week of events from October 13 to 20.

Her selection was announced at a luncheon in the International House which was sponsored by the oil information committee of New Orleans, La.

A secretary to S. Hendricks, superintendent of the International Lubricants New Orleans plant, Miss Fitzgerald has been with the corporation for two and a half years.

Emery Announces New Sales Positions

David R. Eagleson has been promoted to assistant sales manager of the fatty acid sales department of Emery Industries, Inc., G. W. Boyd, sales manager, announced.

Paul N. Leech has been named to succeed Eagleson as sales representative for Emery in the Chicago area.

Eagleson has been a member of Emery's sales staff since 1945, serving as manager of the Chicago office since 1951. In his new position, he will assist in the direction of all phases of sales of Emery's complete line of fatty acids. This includes stearic and oleic acids, hydrogenated fatty acids and glycerides, animal and vegetable fatty acids, and caster oil derivatives.

A graduate of Miami university,

HARSHAW LEAD BASE

Harshaw Lead Base, as an additive to petroleum lubricants, improves extreme pressure characteristics and imparts the following desirable properties:

- **Increased film strength**
- **Increased lubricity**
- **Improved wetting of metal surfaces**
- **A strong bond between lubricant and metal surfaces**
- **Resistance to welding of metals at high temperatures**
- **Moisture resistance and inhibits corrosion**

Harshaw Lead Bases are offered in three concentrations to suit your particular needs:

Liquid	Liquid	Solid
30% Pb	33% Pb	36% Pb

Other metallic soaps made to your specifications. Our Technical Staffs are available to help you adapt these products to your specific needs.

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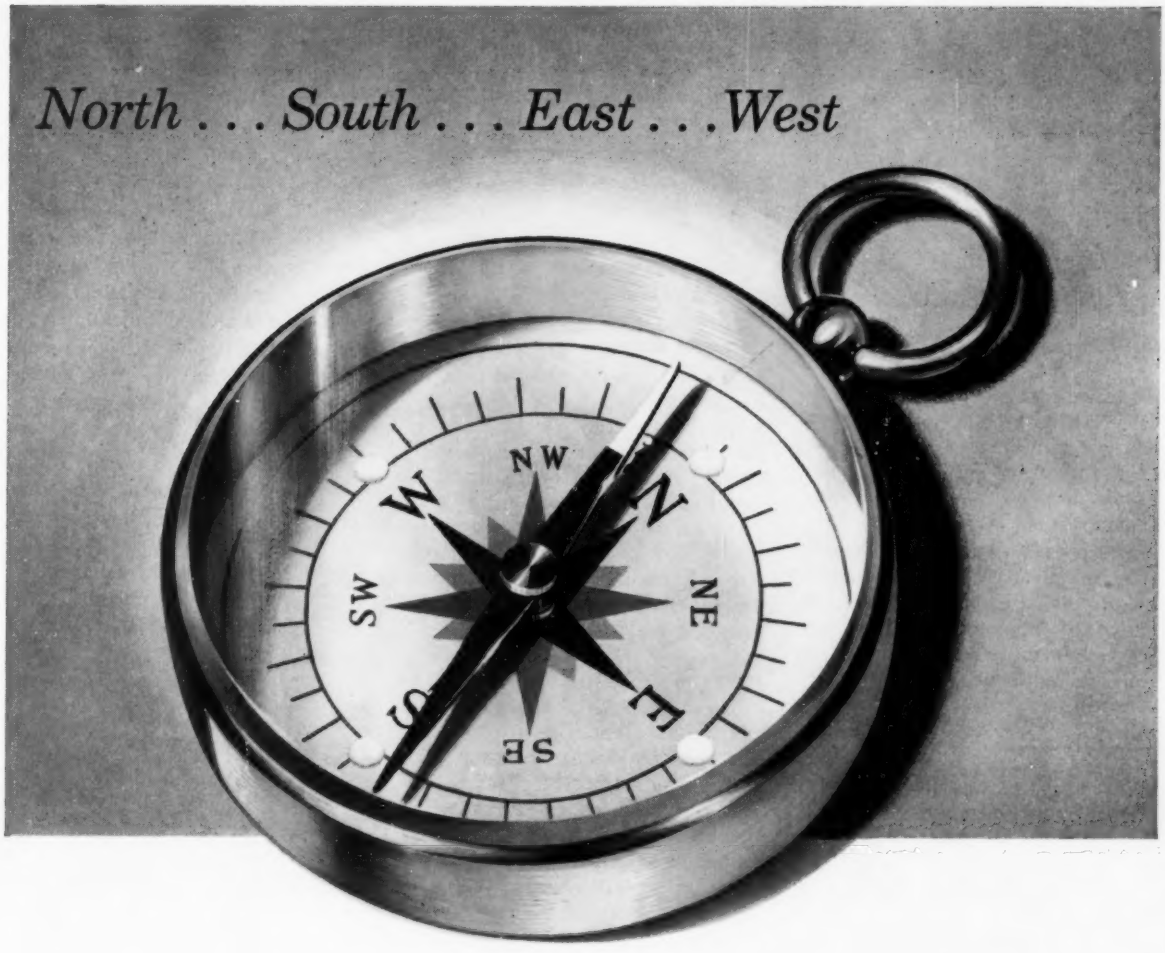

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Shell Alvania Grease, used world-wide as a multi-purpose lubricant, has an outstanding performance record in solving many of the toughest anti-friction bearing grease problems. Ideal for wet, humid applications (inhibited to prevent water corrosion), it lubricates under water-wet conditions which normally spell trouble.

Alvania* Grease has the added advantage of remaining plastic in sub-zero weather and stable under sustaining high temperatures. This one grease successfully replaces dozens of special lubricants in plant after plant . . . reason enough for its universal popularity. For complete information, write Shell Oil Company, 50 West 50th St., New York 20, N. Y., or 100 Bush St., San Francisco 6, Calif.

*Trademark

SHELL ALVANIA GREASE

A TRULY MULTI-PURPOSE LUBRICANT

SHELL

Eagleson Leech

Eagleson is a member of the American Chemical Society; the Paint, Varnish and Lacquer association of Chicago; the Chicago Rubber group, and the Chicago Drug and Chemical association.

Leech is a graduate of Northwestern university and a member of the American Chemical Society. A native of Winnetka, Ill., he has served during the past year as Emery's representative in the mid-Atlantic area.

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In addition to metropolitan Chicago, Leech's new territory includes northern Illinois, Wisconsin, Minnesota, northwestern Indiana and upper Michigan.

Sack Appointed to St. Louis Territory

Joseph Z. Sack has been appointed to the newly-created St. Louis sales territory of the fatty acid sales department of Emery Industries, Inc., G. W. Boyd, department sales manager, announced.

The move is designed to provide increased service for the greater St. Louis area in the sale of Emery's line of fatty acids and glycerides, including stearic and oleic acids, hydrogenated fatty acids and glycerides, animal and vegetable fatty acids, and castor oil derivatives. Emery's merchandising operation in St. Louis will continue unchanged.

Moves Operations Center

Sack has moved his center of operations to St. Louis, which he has serviced during the past year as Emery's south central states representative. Sack's new territory includes Missouri, Iowa, Nebraska, Colorado, southern Illinois, northern Kansas, and western Kentucky and Tennessee.

Sack is a graduate of the University of Kentucky. He is a member of the Associated Drug and Chemical Industries of Missouri.

Lawton Manages New American Potash Offices In Columbus

American Potash & Chemical corporation has opened a new district office at Columbus, Ohio, covering outlets in Ohio, eastern Indiana, southern Michigan and Kentucky.

Formerly District Representative

Chester A. Lawton, who has been with AP&CC since 1950 as district representative in the midwestern area, has been appointed manager of the new district office, which is located at 12 North Third Street in Columbus.

Part of a Three-Year Expansion

Opening of the office is part of a territorial realignment begun three years ago by AP&CC to accommodate the company's greatly increased sales in recent years, according to William J. F. Francis, AP&CC vice president in charge of sales.

"To handle expanded sales during the past five years, we've enlarged the sales staff from 13 to 34 men," Francis said, "and we plan a continued increase in the next few years."

Lawton will be in charge of all company product sales in the new territory under the direction of A. J. Dirksen and E. M. Kolb, eastern general sales managers of AP&CC's industrial chemicals division and heavy chemicals division, respectively.

News continued on page 38

McGEAN 30% LEAD NAPHTHENATE ADDITIVE

Consistently uniform in metallic content and viscosity

Fully clarified by filtration

Non-Oxidizing - - - contains no unsaturated soaps

Free from low flash constituents

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READY FOR WINTER?

"The frost is on the pumpkin and the corn is in the shock." The harvest season for 1957 is just about over. Most crops are safely under cover and now comes the most important job of all. Storage lubrication time. The job that insures that every bearing on the machine is flushed free of the old, dirty lubricant and replaced with fresh, clean lubricating grease. It is the job that assures the farmer that his equipment will wake up next spring, fresh and fit for the summer's long grind. Yes, now is the time to market Bat's 'Quality" Multi-Purpose Lubricating Grease. A grease that—Beats Cold . . . Beats Water . . . Beats Rust . . . Beats Heat. A grease that assures your customers of complete protection. If you are not marketing Bat's "Quality" Multi-Purpose Lubricating Grease, you are losing sales. Write today for information and prices. Make your customer a happy customer. Market Bat's truly, Multi-Purpose Lubricating Grease.

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Industry News

Kerr-McGee Pilot Launches Relic Plane For Love Field Display

It was a nostalgic moment for aviation old timers recently at Oklahoma City's Will Rogers field when a former barn-storming pilot took off in an old World War I trainer that has been airborne only once in 30 years.

With its 150-horse powered Hispano Suiza engine—1917 vintage—purring like an old tractor, the old J-1 Standard took to the air with Ken Hunter at the controls.

The plane took off October 24 to fly from Oklahoma City to Dallas—to be on display at the formal opening of Love field's new facilities, October 25, 26 and 27.

"LUBRICATION in the air" action shot of Kerr-McGee's chief pilot Ken Hunter and brother John during their 23-day record test flight in 1930.

Hunter, chief pilot for Kerr-McGee Oil Industries, Inc., with mechanic Chester Gotschalk, was in the plane's open cockpits on its first extended flight since it was placed in storage 30 years ago. That was back in the days when Ken and his three brothers barn-stormed the midwest.

Hunter and Gotschalk worked four months remodeling and rebuilding the plane before taking it up on its first test flight around the field last year.

Hunter and his brother John, established a world endurance flight record by staying aloft over Chicago for 23 days in 1930. The flight was sponsored by Deep Rock petroleum products; Ken still flies for Kerr - McGee, producers of Deep Rock products today.

The old plane, which was displayed at the National Aircraft Show in Oklahoma City in 1956, is in perfect flying condition.

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LUBRICATION

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Products

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Industrial
Oils and Greases

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and Affiliates: MAGNOLIA PETROLEUM CO.
GENERAL PETROLEUM CORP.

Foote Mineral Company Adds to Research Staff

Recent additions to Foote Mineral company's research and development department have been announced by Dr. E. M. Kipp, director of research.

Dr. David W. Mitchell joins the company as manager of minerals research, at the company's Kings Mountain research laboratories. Mitchell served as associate professor of metallurgy at the University of California for twelve years.

Dr. Justo B. Bravo and Dr. Meyer M. Markowitz have joined the chemical research division as senior research chemist and project leader respectively. A graduate of Adamson university in Manila, Dr. Bravo received his Ph.D from Kansas university in 1953.

Dr. Markowitz, prior to joining Foote, was research chemist at N. Y. U., where he received his undergraduate training. He comcompleted his graduate work at Cornell and received his doctor's degree in inorganic chemistry in 1953.

News continued on page 40

"How'd those last five loads of J&L drums come in, Joe?"

"Checked 'em all with the drop light, Boss. Clean as a whistle... never saw a better lining job."

- J&L specialists, backed up by modern research, are ready to consult on your toughest packaging problems.
- J&L, an integrated steel producer, controls container quality from start to finish.
- J&L steel containers provide engineered packaging for dependable transportation and safe storage.
- Precise fabrication and correct specification of fittings and closures.
- Prompt dependable delivery from nine plants.

Call your nearest J&L Container Division office for recommendations on your packaging problems. Or write direct to the Container Division, 405 Lexington Avenue, New York 17, N. Y.

J&L STEEL

Jones & Laughlin

...a great name in steel

Sonneborn Offers Brochure On Rust Prevention Systems

A four page brochure outlining applications and advantages of the Sonneborn rust prevention system, is now available from L. Sonneborn Sons, Inc., building products division, Dept. EE, 404 Fourth Avenue, N. Y. 16, N. Y.

It includes information on where, when, and how to use S.R.P. 75 Primer for priming rusted surfaces; and S.R.P. 87 Finish Coat, which adheres to and coats metal surfaces with a protective finish.

It tells how these coatings provide greater durability and elasticity in contact with the corrosive elements. Results of adhesion, immersion, fume, electrolytic breakdown accelerated weatherometer, and field performance tests are also pointed out.

In addition, the publication covers complete specifications for the Sonneborn products which comprise the rust prevention system and offers detailed, technical, and packaging and shipping data.

Seventeen applications are pictured in a series of sketches, together with a partial list of SRP users.

H. A. Mayor, Jr., Chairmans Petroleum Packaging Committee Meeting

The petroleum packaging committee of the Packaging Institute met in Sarnia, Ontario, Canada on September 10th and 11th with Imperial Oil company as the host company. Mr. Russ McAllister, coordinator packaging, for Imperial Oil company, was in charge of the arrangements. Mr. H. A. Mayor, Jr., chairman, presided during the business session of the meeting. Mayor is a member of the NLGI Board of Directors.

Mr. F. W. Langner, chairman of the metal drums and pails subcommittee, reported on efforts to improve the construction of the 400 lb. drum. All the drums tested showed no improvement over the drum of the present specifications.

Progress reports were made by the chairmen of the following subcommittees: new packaging materials, shipping cases, box car loading, small metal packages, labels and markings, palletization, wax packaging, asphalt packaging, and publicity.

Mr. R. Chester Reed, vice-chairman of the government industry sub-committee, reported that the Army and Navy will no longer require cap seals on metal drums shipped on their orders or contracts by the petroleum industry. The Air Force will continue to require cap seals on shipments made for their account.

Mr. R. W. Henry, chairman of the standards sub-committee, reported that the universal standards for metal drums and pails, developed and adopted by the committee in 1954, have been submitted to the American Standards Association for issuance as American Standards.

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Reynolds Metals Creates Petroleum-Chemical Special Service Group

Creation of a specialty field service organization to work with the petroleum and chemical industries was announced by Reynolds Metals company.

This is believed to be the first such service group set up in the aluminum industry specifically to serve the petroleum and chemical markets.

Seven engineers trained as specialists in applications of aluminum in these industries staff the new Reynolds group. Two are located in New York and one each in Los Angeles, Houston, Dallas, Tulsa and Maracaibo, Venezuela.

"These engineers are available for consultation or other assistance requested by industry," said W. B. Moore, manager of the petroleum and chemical market for Reynolds. Their assistance in the field is backed up by Reynolds' research, engineering and marketing organization at Louisville and Richmond, Va.

The field engineers and their headquarters are: L. V. Shean (domestic service) and W. H. Caruthers, Jr., (international) at New York; I. C. Scott, Jr., Houston; C. R. Schall, Dallas; D. E. Smith, Los Angeles; Leo Hillman, Tulsa; and Eugene F. Prestera, Maracaibo.

Gulf Oil Creates New Type Plastic Lubricant For Business Machines

A new type of lubricant which possesses qualities of a true plastic and so achieves long-term lubrication has been developed for use in business machines by the research center of Gulf Oil corpor-

Continued on page 42

SWIFT'S INDUSTRIAL OILS
INVITE COMPARISON

Write for a trial order of any of these Swift quality products . . . a trial in your own shop will convince you of their stability and dependability in helping to produce lighter and more uniform lubricants.

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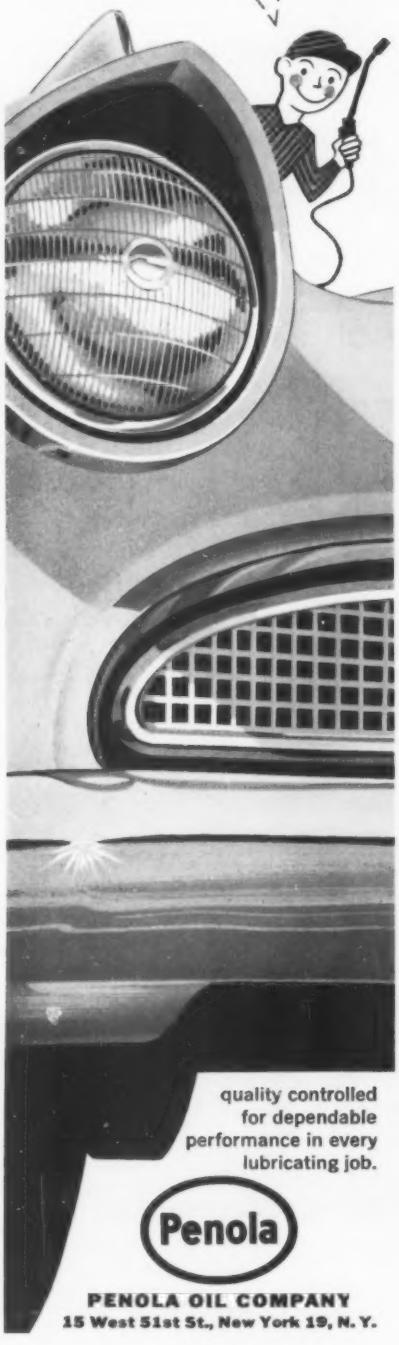
PENOLA AUTOMOTIVE LUBRICANTS



quality controlled for dependable performance in every lubricating job.

Penola

PENOLA OIL COMPANY
15 West 51st St., New York 19, N. Y.

ation. It is named Gulf Plastic Petroleum B.

The new product is thixotropic, which means that while being worked it becomes thin and oily and, when working stops, it returns to the consistency of a light grease. Hence it does not run off, or wear off, the parts it protects.

The new plastic petroleum can substantially extend the life of business machines. Years of testing by the National Cash Register company, which has extensively evaluated the material in its machines, show this lubricant reduces wear of parts considerably below that obtained with conventional lubricants.

Lubricates to 150 Degrees F.

It will lubricate in a range of temperatures from below freezing to 150 degrees F., thus being adapted to cash registers used in outdoor markets from the tropics to northern regions, to typewriters in military service, and to high speed electric calculators which generate considerable internal heat.

Other qualities built into the plastic petroleum include high load-carrying capacity, low friction characteristics, and exceptional rust-preventive action. Very high oxidation stability prevents it from gumming or deteriorating in use.

An exclusive development of the Gulf laboratories, the product's history stretches back more than 20 years to when its original ancestor was designed as a rust-preventive lubricant.

To this quality, during World War II, were added characteristics which permitted operation in extremes of heat and cold, in order to transform the formula into a lubricant for the magazines of anti-aircraft guns, used in all climates.

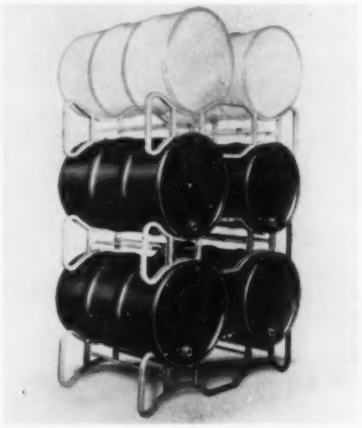
In recent years, Gulf scientists merged the earlier-created qualities with additional characteristics to produce a lubricant fully adapted to business machines. National Cash Register assisted by a full-scale program of evaluating the product.

Machine parts can be easily coated with plastic petroleum by brushing or by dipping in solvent-diluted baths. Now an established brand on the market, it is used in National Cash Register products and is under evaluation by other major business machines builders.

The product represents a unique combination of materials for which patents are pending.

Barrel Rack Developed By Republic Steel

Development of a steel rack designed to permit—for the first time—the handling and stacking of loaded or empty barrels and drums with standard fork lift trucks has



NEW steel rack permits the stacking of loaded barrels and drums without the need for special handling equipment. Ordinary fork lift trucks can be used for handling and stacking.

LET US MODERNIZE YOUR PLANT

C. W. NOFSINGER CO.

Petroleum and Chemical Engineers

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KANSAS CITY 6, MO.

"In Engineering it's the People that count"

been announced by the pressed steel division of Republic Steel.

The new drum rack supports two loaded barrels and makes easy the stacking of pairs of containers to any practical height. Great flexibility of handling and storage is provided because individual drums or pairs of drums can readily be removed without excessive handling of the other drums in the stack.

Eliminates Special Handling

Eliminating the need for special drum handling equipment, the new units are so made that a two-drum lift can be made from either front, back or either side. The same availability applies to a single top drum, for it can be removed from the supporting rack with the tines of the fork lift truck from any side.

The units also make it easy to get at bunged drums for draw-off.

Safe, quick and easy, the drum racks make it possible to store more in-use drums in less space than ever before.

Efficient inventory control is also made simple because of the accessibility provided by this method of storing and handling containers.

Any standard fork lift truck can pick up, move and stack as many tiers of loaded drums at one time as its lifting capacity permits. And handling of loaded containers with the barrel rack is safer because there is little chance of container contact. This is due to the design of the rack which isolates each drum or barrel from the other.

In ordinary practice, stacking drum upon drum often results in dents, punctures, and loss of contents.

The barrel racks are made of heavy gage channel steel, strongly braced and welded. One unit will support 7,500 lbs. in 18 gage drums and 14,000 lbs. in 16 gage drums. The racks are enameled to offset rusting, and are shipped knocked down, individually cartoned.

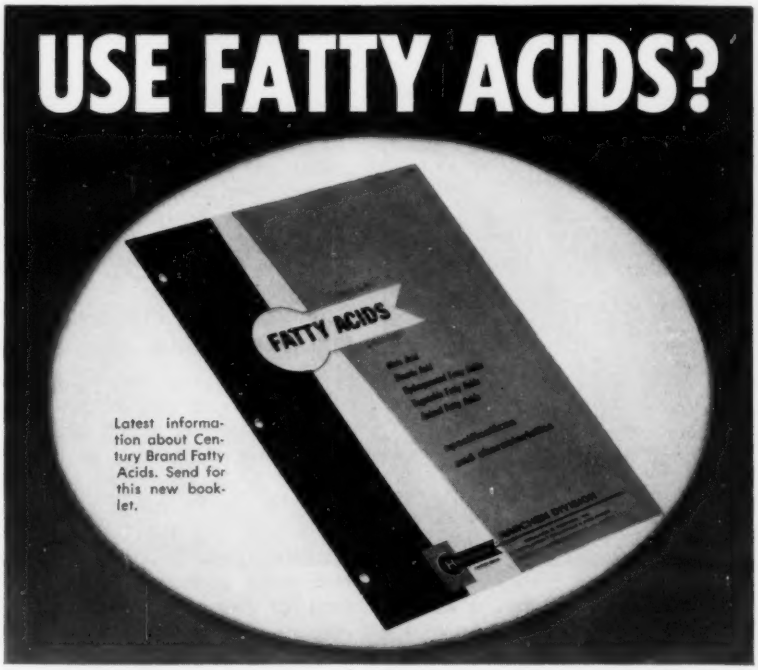
Further information is available from the Pressed Steel Division, Republic Steel Corporation, 6100 Truscon Avenue, Cleveland, Ohio.

Valvoline Publishes Findings on Dirt Particles in Oils

The Valvoline Oil company, Freedom, Pa., have published a folder titled, "The Search for Hidden Dirt." It describes the function of the electron microscope to examine the dispersion of contamination particles in motor oils.

A Valvoline laboratory spokesman in describing the use of the electron microscope said, "At the Valvoline laboratory we observe the action of additives in used oil with the aid of the electron micro-

Continued on page 44



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If you use Fatty Acids you will want Harchem's new publication of specifications and characteristics for their Century Brand Fatty Acids. Harchem gives you the latest data about all grades in their complete line of uniform quality fatty acids. You are the best judge of the type and grade you need. By using this information as a basis for comparison, you can select the fatty acid best suited for your specific use.

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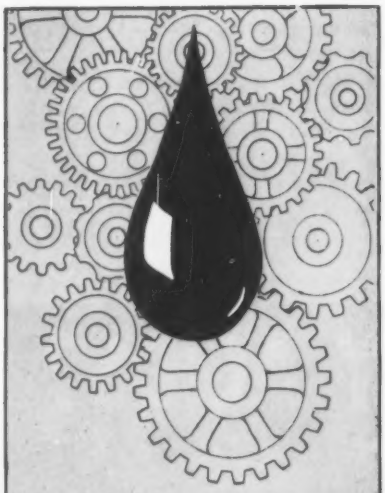

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scope which permits magnification up to 50,000 times of the particles (only a fraction of a micron in size) in suspension. We find that when particles in the used oil reach a size of 1 to 2 micra, engine deposits may start to form. These particles that form are combustion chamber 'garbage' or impurities which are picked up by the additive material and held in suspension The better the dispersion of the additive in the oil the finer these particles remain. This results in a cleaner engine, less varnish-like deposits (on hydraulic valve lifters, piston rings, and other parts) and thus longer engine life by reducing wear."

A copy of this folder can be had by writing to the Valvoline Oil company, Freedom, Pa.

Barrett Offers Precision Filling Machine—The LM-2

A low-cost, precision filling machine for greases and other viscous products has been introduced by Barrett Manufacturing Co., Houston—an NLGI Associate member firm. The Barrett LM-2 filler sells for well under $1,000, making it practical for intermittent or short-run, small container filling. It is used for greases, asphalts, caulking compounds and specialty products.

Capacity Offers Speed Increase

As an example of its capacity, the LM-2 filler enables one man to fill 14 oz. grease cartridges with lithium grease at the rate of 25 to 35 per minute. Unit is available up to four interchangeable cylinders covering a range of from 2 oz. to 38 lbs. Measured volume can be varied by adjusting hex screws at either end of the cylinder.

A treadle-operated air system controls the four-way valve which starts the filling cycle. The product system can be operated by any type pump. The waist-high loading table has a hole positioned under the filling orifice to dispose of cleanout or accidental discharge. Unit is skid mounted; net weight about 400 lbs.

For more information on the LM-filler write: Barrett Manufacturing Company, P.O. Box 8096, Houston, Texas.

Galloway Named an Executive Vice-President Of Shell Oil Company

The Shell Oil company board of directors has designated A. J. Galloway an executive vice-president of the firm.

Galloway has been vice-president in charge of Shell's exploration and production activities since 1948. He will continue to be responsible for this phase of the company's business.

The new position recognizes the increasing importance of exploration and the production of crude oil and gas, according to H. S. M. Burns, president of the company.

Galloway joined Shell in California as a geologist in 1926. He had been exploration and production vice-president for the Mid-Continent and later for the Texas-Gulf area and the East of the Rockies territory before being made vice-president in charge of the company's nationwide exploration and production operations. He has been a director of Shell Oil company since 1953.

Du Pont Section Aids Industrial Maintenance

The Du Pont company's finishes division has recently set up a new technical services sales section to be devoted exclusively to industrial maintenance painting. The new unit will offer specialized assistance in the petroleum, steel, marine fields, as well as with contracting painters doing industrial work and national accounts.

To be known as the "industrial maintenance sales section of the trade sales division" with headquarters in Wilmington, Delaware, the new service group will offer assistance anywhere in the country. Four district managers will be located in Philadelphia, Atlanta, Chicago and Kansas City. West Coast district supervision will remain with regional trade sales and industrial managers in San Francisco.

Cuts cooling cycle 3 hours at Socony Mobil

Continuous grease-cooling with VOTATOR* Heat Transfer Apparatus at Socony Mobil Oil Company, Inc., New York, is producing these benefits compared to batch method:

- **Product uniformity—more easily obtained with automatic, controlled cooling.**
- **Saving of 3 hours in cooling time—with more rapid heat transfer rates.**
- **Simplified housekeeping—with fully enclosed cooling, compact installation.**
- **Sustained operation—because VOTATOR is designed and built to handle round-the-clock processing . . . give you high output, long trouble-free service.**

Find out how *you* can benefit with VOTATOR Grease Processing Apparatus. Call or write for complete information.

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Future Meetings

NOVEMBER, 1957

4-6 SAE National Transportation Meeting, Hotel Statler, Cleveland, Ohio.

5-6 SAE National Diesel Engine Meeting, Hotel Statler, Cleveland, Ohio.

6-8 Society of Automotive Engineers, National Fuels and Lubricants Meeting, Hotel Statler, Cleveland, Ohio.

11 API-OIC, Steering Committee Meeting, Conrad Hilton Hotel, Chicago.

11-13 API Division of Marketing, Annual Meeting, Hotel Congress, Chicago.

11-14 API 37th Annual Meeting, Conrad Hilton and Palmer House, Chicago, Ill.

DECEMBER, 1957

1-6 ASME, Annual Meeting, Statler Hotel, New York City.

3-4 Petroleum Packaging Committee, quarterly meeting, Hotel Washington, Washington.

5-6 API Oil Information Committee meeting, Biltmore Hotel, New York City.

JANUARY, 1958

13-17 Society of Automotive Engineers, Annual Meeting, Sheraton-Cadillac and Statler Hotels, Detroit.

22 Independent Oil Men's Assn., Annual Meeting, Hotel Statler, Boston.

22-23 Northwest Petroleum Assn. Annual Meeting, and trade show, Nicollet Hotel, Minneapolis.

FEBRUARY, 1958

2-7 ASTM Committee D-2 Meeting, Rice Hotel, Houston.

10-14 ASTM National Meeting, Hotel Statler, St. Louis, Mo.

12-14 API Division of Marketing, Marketing Research Committee, Biltmore Hotel, New York City.

26-28 API Division of Production, Southern District Meeting, Shamrock-Hilton Hotel, Houston.

27-28 API Division of Marketing, Lubrication Committee Meeting, Sheraton-Cadillac Hotel, Detroit.

MARCH, 1958

4-6 SAE Passenger Car, Body and Materials Meeting, Sheraton-Cadillac, Detroit, Mich.

19-20 Ohio Petroleum Marketers Association, Annual Convention and Marketing Exposition. Deshler-Hilton Hotel, Columbus, Ohio.

31-Apr. 2 SAE National Production Meeting and Forum, The Drake, Chicago, Ill.

APRIL, 1958

9-11 API Division of Production, Mid-Continent District Meeting, Biltmore Hotel, Oklahoma City.

16-18 National Petroleum Association, Cleveland, Ohio

MAY, 1958

21-23 API Division of Marketing, Midyear Meeting, Roosevelt Hotel, New Orleans

22-23 API Division of Production, Pacific Coast District Meeting, Biltmore Hotel, Los Angeles.

JUNE, 1958

8-13 API Division of Production, Midyear Committee Conference, Hollywood Beach Hotel, Hollywood, Fla.

8-13 SAE Summer Meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

22-28 ASTM 61st Annual Meeting, Hotel Statler, Boston, Mass.

SEPTEMBER, 1958

10-12 National Petroleum Association, Atlantic City, N. J.

OCTOBER, 1958

20-22 SAE National Transportation Meeting, Lord Baltimore Hotel, Baltimore, Md.

22-24 SAE National Diesel Engine Meeting, Lord Baltimore Hotel, Baltimore, Md.

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AT FOOTE the LITHIUM story is 450 feet long

The country's most exhaustive collection of printed material on lithium—its characteristics, compounds, and applications—rests on 450 feet of library shelving at Foote Mineral's Berwyn Research Library. Here is the up-to-the-minute historyof lithium . . . indexed for immediate access to any one of 13,000 references which chemically, physically, and metallurgically describe this most unusual of all metals. Begun more than a quarter century ago when Foote pioneered in the development of lithium, it is still growing at the rate of well over a foot of library shelf a week.

What does this mean to you? Well, lithium and its compounds in a very few years have outgrown the laboratory curiosity stage to become important factors in chemistry . . . ceramics . . . greases . . . organic intermediates . . . nuclear energy . . . to name but a few. Chances are that in the next five years you'll be investigating lithium as it might apply to your field. But when you do . . . before you invest time, effort, and money . . . your ideas will be thoroughly researched in this immense accumulation of data, by men who have played an important part in discovering the facts and creating the literature.

• • •

Write for *Chemical and Physical Properties of Lithium Compounds* and a taste of what Foote's store of lithium information has to offer you. This Data Bulletin is available on request to the Technical Literature Department, Foote Mineral Company, 402 Eighteen West Chelten Building, Philadelphia 44, Pa.

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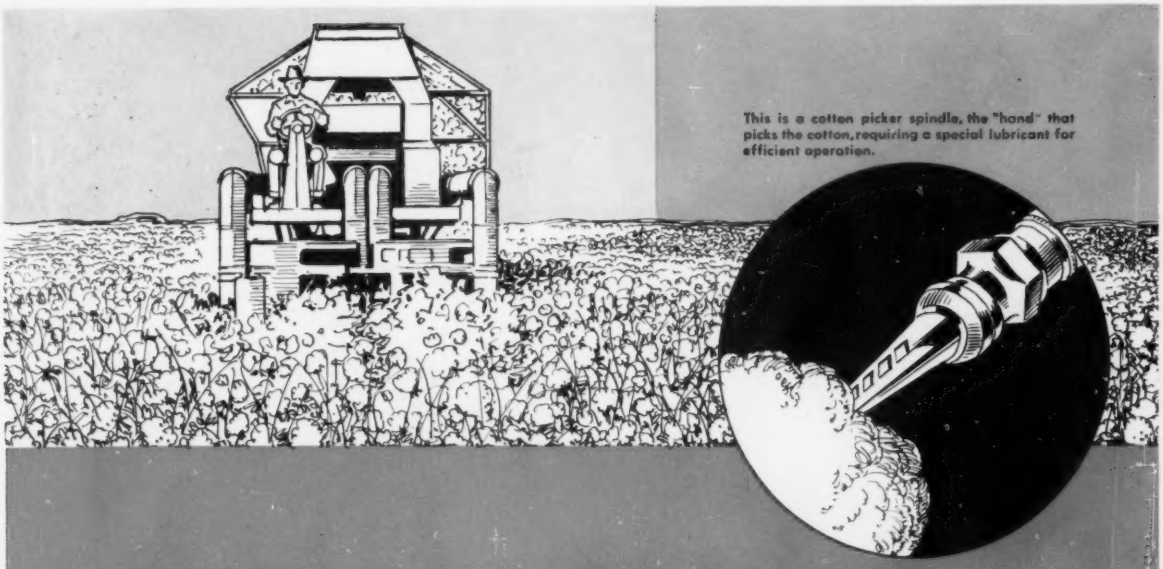

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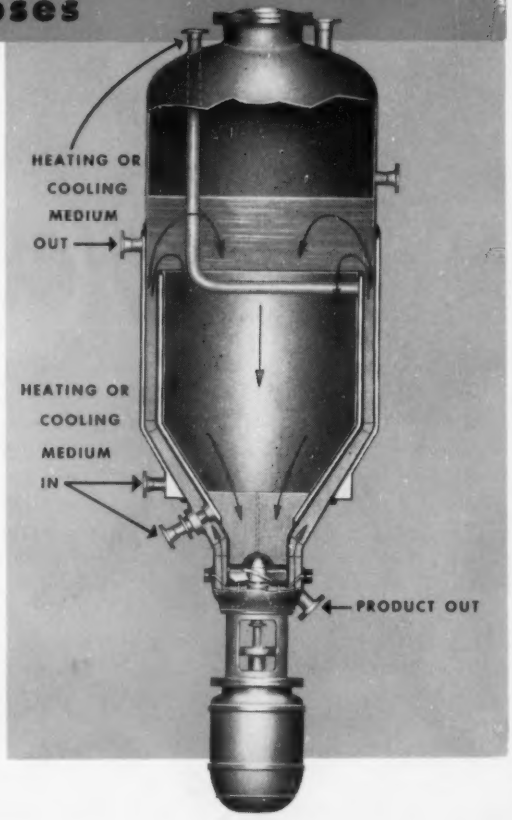

STRATFORD ENGINEERING Corporation

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